JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. MAY, 1890. No. 5

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THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

BY F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

MR. PRESIDENT AND MEMBERS OF THE FRANKLIN INSTITUTE:

Your delegate appointed to examine and report on the progress of the metallurgical arts as exhibited at the International Exhibition, held in Paris in 1889, begs leave to submit the following report:

Owing to the refusal on the part of the French Exhibition officials to recognize any American commissioners other than those appointed by the United States Government, your representative has labored under great difficulties in collecting the materials for his report. In the present instance he has been obliged to take much of his information at second-hand, and for the sake of accuracy, and

a desire to give nothing that is not absolutely correct, he has been obliged to make the report much shorter and in some particulars more incomplete than it otherwise might have been.

During the past eighteen or twenty years the progress of the metallurgical arts in France has been equal to, and I believe in some instances, greater, than in any other country in Europe. Paradoxical as it may seem, disastrous wars are often productive of the greatest good to a healthy, vigorous country. After the close of the Franco-German War, in 1871, the energies of the French people seemed, with one accord, to have been turned to the improvement and increase of their national armaments and railroad systems. This naturally gave an unprecedented stimulus to the iron and steel industries, but it does not, however, seem to have greatly increased the production of pig-iron and steel rails. The demand of iron and steel being mostly for military and naval purposes, the improvement in the metallurgical arts cannot be indicated by the number of tons of this or that kind of iron or steel produced, any more than the improvements and skill used in the manufacture of jewelry and silverware would be indicated by the number of ounces of gold and silver annually produced in the United States. Figures, therefore, might be misleading, and will not be given, except under their specific heads and places in this report. Although the production of war material has had a most important bearing upon the metallurgical industries of France, I find that information relating to it is particularly difficult to obtain, and what little I succeeded in getting amounts to but a few generalities, which, perhaps, may not be unknown to you. I believe it is generally admitted that the French at present surpass all their neighbors in the manufacture of light and heavy ordnance, and that their present facilities for manufacturing large gun forgings, and rolling armor plate are equal to, if not somewhat greater, than any other country in the world. In the matter of iron and steel ship-building the French have progressed very rapidly, and as a naval power rank second to England. In the improvements of harbors, build-

ing of bridges and other engineering works requiring a large consumption of iron and steel an equal progress has been made. Great advances have also been made in the improvements of the railroads, in the motive-power, road beds, and their most excellent terminal facilities.

Turning now from the iron and steel industries to the consideration of the other metals, the French, during the past decade, do not seem to have made so much progress in the metallurgical arts as applied to them, but on the whole, however, they may fairly be said to hold their own.

Taken in its entirety, the great Paris Exhibition of 1889 gave a most satisfactory and vivid representation of the power, resources and wealth of the French nation. To anyone who thought that France had seen her best days it was a great surprise; truly, France is yet a great country, and with a good government, the genius, thrift and industry of the people should make her once again the greatest of the continental powers.

Coming now to the details of the report, I have taken up one by one the metals which are of any especial importance in the arts, leaving iron and steel and the consideration of fuels to the last.

Aluminium.—I observed five different exhibits of the productions of this interesting metal; those of the Oldbury Works, of Birmingham, and the Alliance Aluminium Company, of London, in the British department; of a Swiss Company, located at Neuhausen-on-the-Rhine, using the Héroult process, in the Swiss; of Bernard Frères, of Creil, in the French department, the Société Électro-metallurgique Française, 43 Rue Saint Georges, Paris, with works at Froges and at Champ (Isère); and also that of the Cowles Electric Smelting and Aluminium Company, of Lockport, N. Y., in the American department. None of these exhibits were extensive, and to a casual observer, not interesting. They represent, however, an enormous expenditure of thought, energy and money, as there has been nothing in the history of metallurgy which has attracted so much popular and widespread interest as the reduction and manufacture of this metal. It remains to be determined if the

results obtained are worth the expenditure. It is my opinion that until this metal can be produced as cheap as say tin or copper, it will have but a very limited use in the arts. At the present time, its principal use is in the form of its alloys with copper and iron or steel. The properties of aluminium bronze are well known, when containing ten per cent. of aluminium, an alloy is produced having a tensile strength in the neighborhood of 100,000 pounds to the square inch. Its effects upon the properties, when alloyed in small quantities of iron and steel, are not so commonly known, but are even more striking. In general, it may be said that it lowers the fusing point of iron and steel, and as a rule, produces a more compact and homogeneous metal. This property which aluminium appears to have of lowering the fusing point of difficulty fusible metals is a very valuable one, and will doubtless become of great use in the arts.

The Oldbury Aluminium Works, near Birmingham, are probably at the present time the largest and richest in the world. They use the process invented by Mr. Hamilton Y. Castner, a young American chemist.* It is a modification of the old Deville process, and consists essentially in the cheap production of metallic sodium by means of a carbide of iron in iron retorts; the reaction being as follows:

$$6\,Na\,HO + Fe\,C_2 = 2\,Na + 2\,Na_2\,CO_3 + 6\,H + Fe.$$

As the cost of reducing the aluminium is in direct proportion to the cost of the metallic sodium used for the purpose, the process, as a matter of fact, is chiefly one of producing cheap sodium.

The aluminium oxide ($Al_2\,O_3$) is treated with carbon, chlorine and common salt ($Na\,Cl$) in regenerative furnaces forming a double chloride of aluminium and sodium.

$$Al_2\,O_3 + 3\,C + 6\,Cl + Na\,Cl = Na\,Cl\,Al_2\,Cl_6 + 3\,CO.$$

The aluminium chloride ($Al_2\,Cl_6$) is thus formed with the

* THE FRANKLIN INSTITUTE was the first scientific body to recognize the merits of this process by the award of one of its medals.—F. L. G.

metallic sodium under a flux of cryolite ($Al_2F_6 + 6NaF$) giving the following reaction:

$$Al_2Cl_6 + 6Na = 6NaCl + 2Al.$$

I have been informed that this company is producing aluminium at less than $2.50 per pound, and are getting from $3 to $4 in the London market.* The Alliance Aluminium Company, of London, claim to produce their metal 99·5 per cent. pure. They use the Netto process at their works, at Wallsend-on-Tyne.

Like the Castner process its aim is the chief production of metallic sodium, which is effected by percolating molten caustic soda through a column of hot charcoal in a cast-iron retort. The caustic soda is reduced and the vapors of sodium are condensed. The residue, consisting chiefly of sodium carbonate, is withdrawn through a tapping hole in the lower part of the retort. Each retort produces from 80 to 100 pounds of sodium per day. Again, as in the Castner process, the metallic aluminium is produced by a slight modification of the old Deville process, *i. e.*, the decomposition of a halogen aluminium salt by metallic sodium. Instead of forming a double chloride of aluminium and sodium, cryolite (a double fluoride of aluminium and sodium) is used. The cryolite is melted in a reverberatory furnace and then brought in contact with metallic sodium, the following reaction taking place:

$$Al_2F_6 + 6NaF + 6Na = 2Al + 12NaF.$$

By adding sulphate of aluminium to the 12 Na F, it can be reconverted into artificial Al_2F_6.

$Al_2F_6 + 6NaF + 3Na_2SO_4$ dissolving the $3Na_2SO_4$ out with water.

The Héroult process, used by the Swiss Company, is an electrolytic process very similar to, if not substantially the same as, the Cowles electrolytic process used in this country.

This exhibit was, in some respects, more interesting than the others, as it contained quite a variety of castings, forgings, etc., of aluminium alloys; a cast bronze propeller,

* September, 1889.

about eighteen inches in diameter, specimens of bronzes and brasses ranging from one to thirty per cent. aluminium. The latter alloy was a white, friable metal apparently worthless for any practical purpose. Ferro-aluminium containing as high as twenty per cent. aluminium, and bronzes and brasses forged, rolled and drawn were exhibited. The following table of tests of bronzes and brasses manufactured by this company were made in the Polytechnic School, at Zürich, Switzerland.

	Aluminium content. Per Cent.	Tensile Strength in Kilograms per Square Millimetre.	Elongation. Per Cent.
Aluminium Bronze,	11'50	80'	0'50
" "	11'00	68'	1'00
" "	10'50	63'8	6'30
" "	10'00	62'1	10'50
" "	9'50	56'0	16'10
" "	9'00	51'6	39'20
" "	8'50	48'0	37'80
" "	8'00	45'0	45'70
" "	7'50	40'7	25'50
" "	7'00	35'7	27'30
" "	5'50	44'0	64.00
" Brass,	4'00	69'0	0'50
" "	3'00	60'0	7'50
" "	2'50	52'0	20'00
" "	2'00	48'0	30'00
" "	1'50	45'0	39'00
" "	1'00	40'0	50'00

The Cowles process is not an electrolytic process in the true sense of the term. The action of the electric current is essentially a smelting one. The intense heat produced by the arc formed between the carbon electrodes together with the carbon present reduces the Al_2O_3 to metallic aluminium which is taken up by the metallic copper added to the crucible for that purpose.*

The Héroult process differs in that a large bunch of carbon rods constitute one electrode and the crucible itself the other. Otherwise, the two processes are practically alike, the reduced aluminium being taken up by metallic copper, or some other metal in the same way. The molten alloy thus formed is tapped from the crucible from time to time, thus making the process to a certain degree continuous.

* "Cowles' Electric Smelting Process." JOURNAL OF FRANKLIN INSTITUTE, vol. cxxi, p. 111.

The Société Électro-metallurgique Française exhibited pure aluminium; ten and thirty per cent. aluminium bronzes; aluminium brass with sixty-four per cent. of copper, thirty-three per cent. of zinc and three per cent. of aluminium; ten per cent. silicon copper and fifteen per cent. ferro-aluminium. I do not know what process or processes this company are using.

The establishment of Bernard Frères, of Creil, exhibited a case full of ingots, bars, etc., of aluminium made by the process used by them, which is that of M. Adolphe Minet, also an electrolytic one, in the correct sense of the term. The inventor submits to the influence of the current a mixture of fluoride of aluminium and sodium together with chloride of sodium (cryolite and salt) in the proportions of thirty to forty per cent. cryolite and sixty to seventy per cent. common salt. This mixture is maintained in the state of igneous fusion, the bath being sustained by constant additions of alumina (Al_2O_3), which dissolves freely in the fused fluorides constituting the bath. The electrolysis of this mixture results in the liberation of metallic aluminium at the cathode and of free fluorine at the anode. The latter at once displaces the oxygen of the alumina dissolved in the bath forming fresh aluminium fluoride and the oxygen displaced attacks the carbon anode and is evolved as carbonic anhydride.

The sodium fluoride also undergoes decomposition, yielding up its sodium by interaction with the aluminium fluoride present, thus causing the liberation of an equivalent of aluminium, and reforming sodium fluoride.

It should be observed in this connection, that the process of Hall, at present used by the Pittsburgh Reduction Company, and whose operations have lately attracted widespread attention, is based on precisely the same reactions as those just indicated. Hall dissolves alumina in metallic fluorides (using for the purpose various mixtures) maintained in igneous fusion and decomposes the fused mixture by the electric current, the result of this operation is the production of metallic aluminium in exactly the same way as in the Minet process. The strength of the bath is

similarly maintained by additions of alumina (Al_2O_3) from time to time.

Hall claims, however, that the fluorides in his bath play no part in the electrolysis, acting simply as a solvent of the Al_2O_3; but there appears to be no reason to believe that the sequence of reactions in this process differs from that in the bath of Minet just described. These two processes may, therefore, be considered to be identical in all substantial respects. Which of the two is entitled to precedence in the order of priority, we have not been able to ascertain.

They appear to represent the most advanced state of the art in the economical production of aluminium. The Pittsburgh Reduction Company quote their metal ninety-six to ninety-seven per cent. pure, at $2 per pound in 1,000 pound lots, which is a reduction in price of nearly fifty per cent. over that of all other manufacturers; and, at the present time, we are informed, the works are turning out large quantities of the metal. To what extent Bernard Frères, at Creil, are working this process we have not been able to ascertain. I have, however, been recently informed that they are working it to a considerable extent.

Copper.—Although the French are justly celebrated for their productions of various articles of this metal, with but one exception the exhibits were disappointing. This exception was the exhibit of the Fonderies and Laminoirs de Biache—St. Vaast Pas-de-Calais. It contained a number of large drawn seamless tubes, the largest being ten and one-half metres by thirty-four centimetres in diameter, another ten metres long, seventy centimetres in diameter, and six millimetres thick, and a short one three metres in length, one in diameter, weighing 1,800 kilograms; a number of vats or pans, one 2·45 metres in diameter, eleven metres in circumference, weighing 1,800 kilograms; another 1·40 metres in diameter, weighing 1,500 kilograms; another, three and one-fourth metres in diameter, 1·6 metres in depth, weighing 1,200 kilograms, thickness of metal, fifteen millimetres. Two large sheets of copper, one three by three metres, thirty-three millimetres thick, weighing 3,000 kilograms, the other 8·40 by three metres, fifteen millimetres

thick, weighing 2,900 kilograms. Considering the difficulty of working such large masses of copper, these productions are especially remarkable. The productions of this company in brass were almost equally as good. Messrs. Muller & Roger, of Paris, exhibited some excellent machinery castings in bronze, one cog-wheel weighing 1,600 kilograms.

Bronzes (artistic productions).

For centuries, the French have been celebrated for beautiful artistic productions in bronze; the exhibition was replete of such work of all sizes and degrees of fineness and beauty. Next to the French and Italians, the Russians, probably, produce the most artistic work in bronze. Their exhibit, however, was disappointing, and unless one had previously visited Russia and was familiar with their productions, the above statement would appear far-fetched. Messrs. Chopin, of St. Petersburg, are the most celebrated bronze founders in Russia, but their exhibit at Paris did them small credit, as most of the articles they exhibited were small, inferior, and their whole display poor in comparison to that in their show-rooms in St. Petersburg.

In this connection, it might be well to mention the remarkable display of M. Dalifol & Cie, of beautifully fine and artistic articles of malleable iron. It was, by far, the finest display of such productions I have ever seen.

Zinc.—About the best and only extensive display of articles and products made from this metal, was made by the great Société de la Vieille-Montagne in the Belgian department. This establishment is the largest of the kind in the world and one of the oldest on the continent. The works produced last year 52,426 tons of crude zinc, 48,545 tons of rolled, and 8,109 tons of zinc-white. The profits, for the year 1888, were $834,415, of which $284,595 was applied to their pension fund. The exhibit, although making an excellent display of zinc productions, was of such small dimensions that it did not convey to the general public any idea of the wealth and importance of the company. The principal works and offices are located at Angleur, in Belgium. Their other Belgian works are at Tilff (rolling mills), Valentin-Cocq (foundries and zinc-white works), at Welkenraedt are the

calamine, blende, lead mines and roasting furnaces, at Schmalgraf-Fossey are mines, metallurgical works and machine shops. In Germany, at Lüderich, blende and galena mines; Steinbruck construction works; Immekeppel, Castor, Colombus, Neu-Moresnet, Nicolaus, Phenix, Weisloch, Borbeck, Oberhausen, mines, foundries, metallurgical works, machine shops, etc. In France, Levallois-Perret, zinc-white works; Bray and Dangu, rolling mills, etc.; Viviez (Aveyron) foundries; Panchot (Aveyron) and Haumont (Nord) rolling mills, etc.

In Algeria and Tunis, calamine, blende and lead mines. In Sweden, at Ammeberg, zinc, copper, cobalt mines, roasting furnaces and machine shops. In Sardinia, calamine mines and machine shops. In Spain, several agencies for the exportation of minerals.*

This company manufacture zinc in nearly all its commercial forms, extra pure, a next grade for uses in the arts, zinc-tin, zinc for galvanizing; zinc-white, various oxides, and silicates for paint, etc.; rolled zinc, sheets for roofing purposes, electrolytic piles, etc.

One of the most interesting exhibits in the French department was that of the Cahaignes process, for the manufacture of chemically pure zinc. This zinc seems to be particularly well adapted for voltaic batteries. Judging from the reports of various chemists that have examined the metal, it appears to be all that is claimed for it; namely, perfectly free from copper, lead, arsenic, sulphur, silicon, etc.

Tin.—I did not observe any notable exhibits of tin, tinned articles or tin-plate. In several instances, however, I observed decorated and stamped articles made of tin-plate, and I understand that this decoration and stamping into cans for preserved fruits, ornamental boxes, etc., has become quite an extensive industry in France.

The French have manufactured more or less tin-plate for a great many years, the first works appear to have been started at Mansvaux, in Alsace, about the year 1714, this

* A very good and descriptive article on this company and its works was published in *Le Génie Civil*, September 28, 1889.

was several years before the industry was established in England and Wales. The successful works started at Mansvaux, in Alsace, were followed by those of Bains, in Lorraine, in 1733; Impy, near Nevers, in 1745, and Morambeau, in Fanche Comte, 1751. Ten years ago the French works produced over 300,000 boxes of tin and terne* plates; I have been unable to obtain any accurate estimate of the present production, but I think it is about 500,000 boxes. France produces no metallic tin, it is all imported from Australia or the Straits of Malacca, I believe little or none comes from Cornwall.

Gold.—There were numerous displays of gold ore, etc., from several of the South American states and the French and English colonies. In some instances, the methods of mining, concentrating and smelting the ore were illustrated with models and drawings. Excepting the numerous, and in several instances magnificent, displays of jewelry, the only other interesting exhibit of which should properly come under the head of gold and gold productions, was that of the Comptoir-Lyon-Alemand. They exhibited what was claimed to be *chemically pure gold*, that is, as I understand it, 1,000 parts fine. I do not believe it is possible to prepare gold *absolutely pure*. The purest of which I have any knowledge, was prepared by W. C. Roberts, Chemist of the Royal Mint in London.† He succeeded, by a most refined and complicated chemical process, in producing the gold 999·96 parts fine. The exhibit of this company included some excellent samples of gold foil, sheets, wire, etc.

Silver.—The exhibits of silverware were numerous, and in many cases interesting and beautiful, the French and English silversmiths made a particularly good showing, but so far as I am aware, they exhibited no novelties, either of design, finish or workmanship. The best, most interesting and novel exhibit of silverware was undoubtedly that of Messrs. Tiffany, of New York. Americans have long been celebrated for their repoussé work in silver and one

* Terne plates are coated with an alloy of tin and lead.

† *Fourth Annual Report of Royal Mint*, 1874, p. 46.

could not help observing that the exhibits of this kind in the American department far exceeded those in any of the other departments, in workmanship and beauty. Messrs. Tiffany exhibited a number of novelties, that is as far as America is concerned, for I believe they are the first Americans that have produced any enamelled and nielloed silver. The art of enamelling silver is a very old one, having been known to the Greeks, and it is probably from this source, though the Byzantines and modern Greek Church that the Russians have derived the art. Outside of Russia, it seems to be almost one of the lost arts, although I believe the French, Italians and Swiss produce some small amounts.*

The art of enamelling consists essentially in laying powdered glass of different colors over a prepared metallic surface, and then heating in a furnace to fuse and unite it with the metal. The cloisonné enamel is made by soldering filigree bands to the surface of the metal, and then filling these enclosures with the fused glass. When the metal is sufficiently thick, the cavities to hold the enamel are cut or dug out of the metal, this kind of work is known as *champlëre.*

The art in producing on silver what is known as *niello* designs, seems to be, like enamelling, almost one of the lost arts, for, as far as I know, with the exception of a small amount made by Tiffany & Co. for the exhibition, none is produced outside of Russia at the present time. Like enamelling, the art consists essentially in fusing into an excavated design on the surface of the silver, an alloy made of silver, copper and lead, the lead constituting about fifty per cent. of the whole.

Messrs. Tiffany's exhibit contained some excellent samples of the oxidized and etched silver. The so-called oxidized silver is, in fact, nothing but a treatment of the articles to a hot solution of sulphide of potassium until they acquire a sufficiently dark color. The various parts are then brushed or burnished to produce the different shades. The brownish tints are produced with chlorine.

* The Chinese and Japanese produce a good deal of cloisonné on bronze and brass, but, as far as I am aware, none on silver.—F. L. G.

The etching on silver is produced in the same way as on iron or steel, that is, by tracing the design on the surface coated with wax and submitting the exposed parts to the action of nitric acid. Etching, and the so-called oxidizing of silver articles is quite a common practice, and productions of this kind were common in a number of the departments.

The Comptoir-Lyon-Alemand exhibited an interesting collection of silver ingots, bars, sheets, ribbon wire, etc. They also claimed to have silver 1,000 fine; but like the gold, I do not believe it is possible for them, or anyone else to obtain such a degree of purity. I have never heard of silver more than 999·9 parts fine. Excepting numerous displays of silver ores, etc., I observed nothing else of especial interest under this head.

Platinum.—The best display of articles made of this metal was that of Messrs. Johnson Matthy & Co., Hatton Garden, London. It consisted of large retorts, stills and laboratory utensils, several large nuggets of native platinum, and good size *ingots* of palladium, indium, rhodium and ruthenium. There was also a large jar filled with granules and pellets of osmium (osmiamic acid probably). Metallic osmium cannot be cast into ingots, for, as far as I am aware, it has never yet been successfully fused. When heated to a temperature at which indium is fully melted, it evaporates and deposits in the form of a black powder on a cold surface held in the vapor, whilst it takes fire in the air, and forms the tetroxide. The Comptoir-Lyon-Alemand, before referred to, exhibited specimens of platinum in the various forms of foil, sheets, ribbon, wire, etc.

Nickel.—There were several interesting displays of pure nickel articles in the various French departments. In the New Caledonian exhibit I observed a bowl of pure hammered nickel, all in one piece, 40 centimetres in diameter and 17 centimetres in depth, the sides being about one millimetre in thickness. Also, two large bars of pure nickel, 2 centimetres in diameter by 40 in length, together a somewhat extensive display of pure nickel in sheets, ingots, etc. I understood that all these articles were made in the colony

from the large deposits of nickel ore (garnierite) occurring there.

Messrs. Bredeville & Paturel, 5 Rue Mazet, Paris, had a large and exceedingly interesting exhibit of kitchen and laboratory utensils made of pure nickel. In regard to the use of pure nickel and nickel-plated culinary utensils, it should be observed that it is well known that acids have a more or less solvent action on nickel and on nickel plating; and inasmuch as the use of nickel and nickel-plated kitchen utensils are becoming general in France and Germany, it is a matter of serious moment to determine what would be the effect upon the human organism of the nickel which may find its way into the food prepared in such vessels. An investigation, having this purpose in view, was made a few years since by Geerkens, who affirms that as much as one-half gram of nickel may be taken into the stomach, and repeated a long time, without producing any noticeably bad effects. When it is considered that the quantity of nickel, which, by any probable means, could find its way into food prepared in nickel vessels, would only be a very fractional part of this quantity, there would seem to be no grounds for uneasiness in the use of the same, especially where the same precautions are used as in the case of copper utensils; that is, thoroughly cleansing them and avoiding the storing of food in them.*

Nickel vessels are found very useful and convenient in chemical manipulations, being quite as good as silver and, of course, much cheaper. Nickel, indeed, is slightly attacked by melted potash, but so is silver. Nickel crucibles have also the great advantage of melting at a much higher temperature than silver, it frequently happens that inexperienced chemists melt their silver crucibles in heating them in a gas flame, but such an accident is not to be feared with nickel crucibles.

Ferro-Nickel.—The French Ferro-Nickel Company, depot 17 Rue Du Pont-aux-Choux, Paris, works Lizy-sur-Ourcq

* See *Report on Nickel, U. S. Mineral Resources.* Williams. 1883 and 1884.

(Seine-et-Marne), exhibited pure malleable nickel, ferro-nickel, nickel steel. They also claim to produce an alloy specially well adapted for covering small rifle-balls. This alloy, ferro-nickel, is attracting considerable attention and the interesting results obtained with it demand our close attention. I have, therefore, taken the following details from a paper on the subject by Mr. James Riley, of Glasgow, published in the *Journal of the Iron and Steel Institute*, May, 1889.

The alloy can be made in any good open-hearth furnace working at a fairly good heat. The charge can be made in as short a time as an ordinary "scrap" charge of steel—say about seven hours. Its working demands no extraordinary care; in fact, not so much as is required in working many other kinds of charges, the composition of the resulting steel being easily and definitely controlled. No special arrangements are required for casting, the ordinary ladles and moulds being sufficient. If the charge is properly worked, nearly all the nickel will be found in the steel—almost none is lost in the slag, in this respect being widely different from charges of chrome steel.

The steel is steady in the mould, it is more fluid and thinner than ordinary steel, it sets more rapidly, and appears to be thoroughly homogeneous. The ingots are clean and smooth in appearance on the outside, but those richest in nickel are a little more "piped" than are ingots of ordinary mild steel. There is less liquation of the metalloids in these ingots, therefore liability to serious troubles from this cause is much reduced. Any scrap produced in the subsequent operations of hammering, rolling, shearing, etc., can be remelted in making another charge without loss of nickel. The importance of this fact will be at once appreciated, especially by users of articles made of this metal, seeing that scrap and old articles will have a value for remelting in proportion to their contents of nickel.

No extraordinary care is required when reheating the ingots for hammering or rolling. They will stand quite as much heat as ingots having equal contents of carbon but no nickel, except perhaps in the case of steel containing

over twenty-five per cent. of nickel, when the heat should be kept a little lower and more care taken in forging.

If the steel has been properly made, and is of correct composition, it will hammer and roll well, whether it contains little or much nickel; but it is possible to make it of such poor quality in other respects that it will crack badly in working, as is the case with ordinary steel.

In endeavoring to obtain a correct idea of the value or usefulness of alloys of nickel and iron or steel, we shall find it of use to consider their behavior under tensile and other mechanical tests, and if these were sufficiently numerous our task would not be a very difficult one.

If it be remembered, however, that in the composition of nickel steel we have present nickel and manganese and iron, with carbon, silicon, sulphur, and phosphorus, and that even a very small difference in contents of some of these has a considerable influence on the character of the alloy, it will be evident that several series of tests (involving a very large number of separate experiments) are necessary to a full investigation. For instance, we all know the effect of very small increments of carbon in steel; hence to estimate correctly, the influence of the addition of nickel, the carbon (as well as manganese and other contents) should remain constant. Then that contents of nickel should be constant and the carbon, etc., varied. Further, that the subsequent treatment of all the products should be identical in every particular.

In Table No. 1 there are several points of interest which it is desirable to notice.

(1) In No. 6 test the carbon present (0·22) is low enough to enable us to make comparison with ordinary mild steel, which would give (when annealed) results about as follows: E. L. sixteen tons, B. S. thirty tons, extension twenty-three per cent. on eight inches, and contraction of area forty-eight per cent. Therefore in this case the addition of 4·7 per cent. of nickel has raised E. L. from sixteen to twenty-eight tons, and the B. S. from thirty up to 40·6 tons, without impairing the elongation or contraction of area to any noticeable extent. In No. 3 test somewhat similar results are found,

No. 1.—Tests of Steel with Varying Contents of Nickel.

Mark.	Composition Per Cent.			Tensile Strength as Cast.					Tensile Tests as Cast and Annealed.					Tensile Tests as Rolled.					Tensile Tests as Rolled and Annealed.					Remarks.
	Ni.	C.	Mn.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	E. L.	B. S.	Extension Per Cent. in 8 in.	Extension Per Cent. in 4 in.	C. A.	
	per ct.	*per ct.*	*per ct.*	*tons.*	*tons.*			*per ct.*	*tons.*	*tons.*			*per ct.*	*tons.*	*tons.*			*per ct.*	*tons.*	*tons.*			*per ct.*	
1.	1·0	·42	·58	Test-piece defective.					27·3	54·6	—	1·5	9·5	32·1	57·6	—	11·0	24·0	30·1	55·1	—	18.7	45·0	
2.	2·0	·90	·50	Too hard to machine with musket-steel. Makes a fine tool tempered at dull red in boiling water.																				
3.	3·0	·35	·57	19·8	34·9	—	2·5	5·6	24·0	34·9	—	2·5	9·0	31·4	51·0	—	20·3	37·0	28·0	48·5	—	20·3	42·0	
4.	3·0	·60	·26	—	—	—	—	—	—	—	—	—	—	29·4	51·5	9·0	10·1	9·0	30·3	42·9	7·5	9·0	12·0	
5.	4·0	·85	·50	Too hard to machine with musket-steel. Makes a fine tool tempered at dull red in boiling water.																				
6.	4·7	·22	·23	—	—	—	—	—	—	—	—	—	—	25·1	40·5	17·75	23·4	42·0	28·0	40·6	20·0	25·0	44·8	Average reduced by one piece, giving low result.
7.	5·0	·30	·30	—	—	—	—	—	—	—	—	—	—	30·0	46·4	10·0	12·3	22·5	28·0	42·6	15·0	17·5	18·5	
8.	5·0	·30	·34	—	—	—	—	—	—	—	—	—	—	31·1	52·0	14·0	15·6	14·0	32·5	46·8	13·5	14·0	17·0	
9.	10·0	·50	·50	Too hard to machine. Makes a good cutting tool when tempered in cold air-blast.																				
10.	25·0	·27	·85	—	—	—	—	—	—	—	—	—	—	38·2	51·4	10·5	11·7	—	12·75	45·8	29·0	30·0	28·6	
11.	25·0	·82	·32	—	—	—	—	—	—	—	—	—	—	22·0	47·6	43·5	47·6	60·0	15·1	42·1	40·0	45·3	43·6	
12.	49·4	·35	·37	—	—	—	—	—	—	—	—	—	—	20·5	37·4	—	12·0	24·0	21·0	37·0	—	20·0	29·0	

E. L. = Elastic limit. B. S. = Breaking strain. C. A. = Contraction of area.

with an addition of only three per cent. of nickel, combined with an increase of the carbon to 0·35 per cent.

(2) In Nos. 2 and 5 tests there is extreme hardness, due in part to the large quantity of carbon present, but also to the presence of nickel in addition. In No. 9 test, with the carbon very much reduced, this characteristic of hardness is intensified by the increase of nickel to ten per cent.

This quality of hardness obtains as the nickel is increased, until about twenty per cent. is reached, when a change takes place, and successive additions of nickel tend to make the steel softer and more ductile, and even to neutralize the influence of carbon, as is shown in No. 11 test, in which there is twenty-five per cent. of nickel and 0·82 of carbon. In this matter of hardness, due to increased increments of nickel, there is some resemblance to manganese steel, as described in Mr. Hadfield's admirable paper.*

(3) In the twenty-five per cent. nickel steel, there are some peculiar and remarkable properties. In the unannealed specimen, the B.S. is high and the E.L. moderately so; but in the annealed piece, while the B.S. remains good, the E.L. is very greatly reduced, down to one-third of the B.S. Again, in both cases, the ductility as shown by the extension before fracture is marvellous, reaching forty per cent. in eight inches. Another feature (clearly brought out in tests Nos. 10 and 11, most in No. 10, by the small contraction of area) is that this elongation is nearly uniform throughout the piece.

Table No. 2 gives results of torsion tests.

In the right-hand column, headed "Remarks," is given the number of sample or test in Table No. 1, for reference as to tensile, strength, etc.

The torsion tests have been made on the steel in the condition in which it left the hammer, and also after having been annealed.

Mr. Riley says: "I have arranged both classes in what we consider order of merit, having regard to all the three

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* Read before the Institution of Civil Engineers, London, February 28, 1888.

No. 2.—Torsion Tests.

Mark.	Number of Twists in 3-inch Length.	Diameter of Bar 1 inch Lever 1 foot long. Weight in Pounds.		Condition.	Composition Per Cent.			Remarks.
		Elastic Limit.	Breaking Strain.		Ni.	C.	Mn.	
1,	1⅛	857	1,849	As hammered.	1·0	0·42	0·58	No. 1 Sample in No. 1 Table (unannealed).
2,	2⅛	677	1,507	"	5·0	0·30	0·30	" " " "
3,	1⅝	665	1,779	"	3·0	0·35	0·57	" " " "
4,	1⅝	621	1,493	"	4·7	0·28	0·23	" " " "
5,	2⅜	553	1,554	"	9·0	0·35	—	" " " "
6,	3	510	1,950	"	8·5	0·27	0·85	" " " "
13,	1⅝	697	1,809	Annealed.	1·0	0·42	0·58	" " " (annealed)
24,	2⅜	653	1,485	"	5·0	0·30	0·30	" " " "
44,	2⅜	652	1,443	"	4·7	0·22	0·23	" " " "
64,	5	360	2,100	"	8·5	0·27	0·85	" " " "
7,	1 15-16	601	1,689	As hammered.	—	0·51	—	47·2 tons per square inch, Siemens steel.
18,	1 9-16	601	1,697	"	—	0·51	—	50·4 " " " "
9.	3⅛	445	1,239	"	—	—	—	30·1 " " " "

qualities of B.S., E.L., and ductility, as shown by number of twists borne by each. It is satisfactory to find that to obtain the best results it is not necessary to use the steels rich in nickel, as only one per cent. is present in that which stands first in both classes.

"There are several interesting points in this table to which I would ask your consideration. (1) At the foot of it, I give results of torsional tests on Siemens steel. Nos. 7 and 8 are tests of the same steel annealed and unannealed, having a tensile strength of 47·2 and 50·04 tons respectively. A comparison of these two shows a very slight improvement in ductility due to the annealing. Now, compare them with No. 9, which is a test of ordinary mild steel of thirty tons tensile strength, and it will, I think, be concluded that it would be better to sacrifice some of the ductility shown by the greater number of twists, in order to obtain some of the greater strength shown in the higher E.L. and B.S. of Nos. 7 and 8. It has become common to order propeller and other shafts of mild steel, but I am inclined to the opinion that their resistance to both stress and wear would be increased by the use of stronger steel, while still leaving an ample margin of ductility. But this is incidental.

(2) "I would ask you next to compare the results obtained with the ordinary steel with those of the nickel steel, and I think there will be no hesitation in deciding that there will be a very great advantage gained by the use of the latter—advantage either in reduction of scantling or in increased strength and ductility.

(3) "It is interesting to notice how very closely this series of tests confirms those in Table No. 1, the E.L. and B.S. in both annealed and unannealed samples corresponding, and having the same relation to each other in both systems of tests, while the number of twists corresponds closely to the ductility as measured by extension in the tensile tests.

"There are a few other properties of these alloys to which I will briefly refer. The specific gravity of nickel is given as 8·66 (we make it 8·86); that of ferro-nickel, if twenty-five per cent. nickel, 8·08; that of ten per cent. nickel, 7·866; that of five per cent. nickel, 7·846; while the mean of our results of hammered steel is 7·84.

"The whole of the series of nickel steels up to fifty per cent. nickel take a good polish and finish, with a good surface, the color being lighter with the increased additions of nickel.

"In the very important matter of corrodibility, it is with the greatest satisfaction I can state that the steels rich in nickel are practically non-corrodible, and that those poor in nickel are much better than other steels in this respect. Thus, some experiments we have made show that, as compared with mild steel of 0·18 carbon, five per cent. nickel steel corrodes in the ratio of 10 to 12, and, as compared with steel having 0·40 carbon, with 1·6 chromium, in that of 10 to 15. In the case of twenty-five per cent. nickel steel, these ratios are as 10 is to 870, and 10 to 1,160, respectively. These results were obtained by emersion of samples of the different steels in Abel's corrosive liquid, and the results confirmed by subsequent immersion in water acidified by hydrochloric acid. Some samples of the richer nickel steels which have been lying exposed to the atmosphere for several weeks still show an untarnished fracture.

"The alloys up to five per cent. of nickel can be machined with moderate ease; beyond that strength they are more difficult to machine. The poorer ones stand punching exceedingly well, both as rolled and after annealing. The punch-holes can be put as close together as one-eighth inch without the metal showing any signs of cracking.

"The one per cent. nickel steel welds fairly well, but this quality deteriorates with each addition of nickel.

"The poorer alloys do not show any lustre, but the richer ones have a lustrous appearance when the scale is removed

"I do not think I have anything more to add as to the properties and qualities of these alloys, but it may be interesting to state the theory held by the inventors regarding their formation. They state that they adopt M. Chernoff's view of steel—that it is composed of crystals of metallic iron, cemented together by carbide of iron; and they account for the extra strength given to steel by nickel by its alloying with this carbide of iron to form a stronger cement that the space between the crystals of iron is thus more

completely filled, and the cohesion between them rendered much more powerful; that the points of solidification of the cement and crystals are nearer, producing or maintaining a more intimate interweaving of the elements; that their process of manufacture is necessary to cause the nickel to enter into combination and produce a homogeneous alloy, as without it there would only be formed a mechanical mixture, not possessing homogeneity, malleability or ductility."

[*To be continued.*]

"WATER RAM" IN PIPES.

By Irving P. Church, Ithaca, N. Y.

[*Concluded from vol. cxxix, page 336.*]

Uniformly Retarded Closing.—With "uniform closing" it has been shown that a large reduction of velocity in the pipe is not brought about until a very late period of the motion of the gate, whether in employing the word "late" we look at the reduction of area of orifice or the time elapsed (for they are proportional in uniform closing); with corresponding great pressure at the end of the closing, while that during the greater part of the time t_0 is small. It readily appears, therefore, that a more rapid motion of the gate at the beginning, followed by a much slower rate of progress at the end, will, *without any change in the total time* t_0, cause the pressure to preserve a more constant value, and thus reach a maximum of necessarily smaller amount than before; since the average pressure (average on a *time* basis) is the same, for the same original data. A rate of reduction (of area of orifice) producing this result may be formulated by making the ratio $\frac{F}{F_0}$ equal to some power (of an index greater than unity) of the ratio $\frac{t_0 - t}{t_0}$; the higher the index the more extreme the difference between the initial and final

rate of motion of the gate. So far, the writer has tried the index 2 only, and suggests the name of "uniformly retarded" for this law of closing.

Accordingly, assume—

$$\frac{F}{F_0} = \frac{(t_0 - t)^2}{t_0^2}; \text{ i. e, } x = \left[\frac{t_0 - t}{t_0}\right]^2; \tag{14}$$

which is to replace eq. (1) of previous work. Eqs. (2) and (3) still hold, and therefore (4) also.

With a value for F, then, obtained from (14), we substitute in (4), and obtain—

$$2\,l \cdot \frac{d\,u}{u^2} = -\,t_0^4 \frac{d\,t}{(t_0 - t)^4} + d\,t \tag{15}$$

As before, we note that $d\,t = -\,d\,(t_0 - t)$ and, hence, can integrate simply (with upper limits variable), obtaining

$$2\,l \left[\begin{matrix} u \\ u_0 \end{matrix}\right. \left(-\frac{1}{u}\right) = \left[\begin{matrix} t \\ 0 \end{matrix}\right. \left(-\frac{1}{3} \cdot \frac{t_0^4}{(t_0 - t)^3} + t\right) \tag{16}$$

Inserting the limits and eliminating t in terms of x from eq. (14), also putting $u = x\,v$, we have finally—

$$v = \frac{u_0}{x + \frac{u_0\,t_0}{6\,l}\left[\left(\frac{1}{x}\right)^{\frac{1}{2}} + 3\,x^{\frac{1}{3}} - 4\,x\right]} \tag{17}$$

This equation takes the place of (8) of the discussion of uniform closing, in the present case of "uniformly retarded closing;" and with it we re-write (9) and (10), as—

$$u = x\,v; \tag{18}$$

and

$$\frac{p - p_0}{\gamma} = \frac{v^2 - u^2}{2\,g} \tag{19}$$

Example of Uniformly Retarded Closing.—Let the data be the same as in ex. 1 of the uniform closing, viz: the length of pipe is $l = 10{,}000$ feet, the whole time t_0 is 600 seconds, and the initial value of the velocity of water in pipe is $u_0 = 6$ feet per second.

Denote the function—

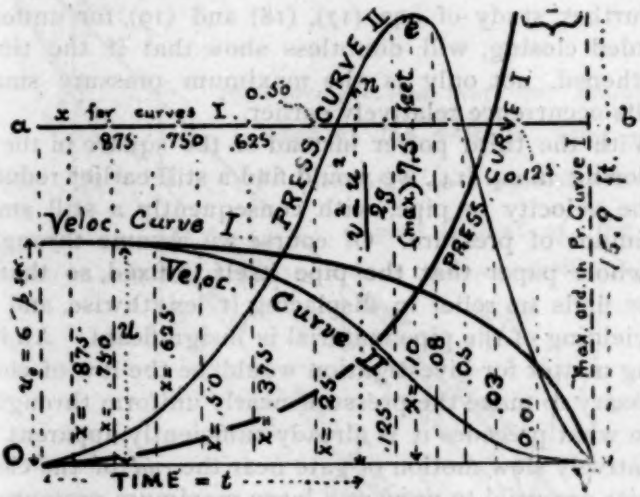
$$\left[\left(\frac{1}{x}\right)^{\frac{1}{2}} + 3\,x^{\frac{2}{3}} - 4\,x\right] \text{ by } X.$$

For a series of values of x, the following results were computed:

t (Sec.)	x (Abs. No.)	X (Abs. No.)	v (Ft. per Sec.)	u (Ft. per Sec.)	$v^2 - u^2$	$\frac{p - p_0}{\gamma}$ (Feet.)
0·0	1·000	0·000	6·00	6·00	0·0	—
37·0	·875	·028	6·84	5·98	11·0	—
79·8	·750	·104	7·92	5·94	24·44	—
124·8	·625	·249	9·36	5·85	53·38	—
174·6	·500	·477	11·34	5·67	96·41	—
231·6	·375	·821	14·16	5·31	171·8	—
300·0	·250	1·375	18·06	4·51	305·6	—
387·0	·125	2·456	22·02	2·75	476·4	—
409·8	·100	2·849	22·14	2·21	485·1	7·5
429·6	·080	3·280	21·96	1·76	479·0	—
465·0	·050	4·300	19·44	·97	377·0	—
495·0	·030	5·643	16·26	·48	263·0	—
540·0	·010	9·603	10·26	·10	105·0	—
600·0	0·000	Infin.	0·00	0·00	0·0	0·0

In *Fig. 2* we have this new law of closing represented by the parabola $A \ldots w \ldots V$, vertex at V and axis perpendicular to $O\,V$, the time axis. For instance, if the time $= \frac{1}{2}\,t_0 = \frac{1}{2}\,\overline{O\,V}$ we raise the ordinate $d \ldots w$ at the middle of $O\,V$ to find the intersection w, which projected on the axis $O \ldots A$ gives a value of $x = \overline{Ok} = \frac{1}{4}\,\overline{AO}$; that is, when the time is half gone the orifice is three-quarters closed, instead of half-closed, as with uniform closing. For the particular numerical example in hand the plotted values of $v^2 - u^2$ (proportional to the effective bursting pressure) result in the curve $A\,P''\,O$, marked "Press. Curve II," whose maximum ordinate is $e\,n$ and has a value less than one-half of that, $O\,M$, of pressure curve I. The velocity curve II shows the decrease of u with lower and lower positions of the gate. For the same gate positions the decreased values of u for the two different laws of closing evidently differ but little; and thus at first sight it is not apparent that reduction of the velocity in the pipe takes place more rapidly for the second than for the first law of closing; nor do the two pressure curves of *Fig. 2* seem to have the same average (horizontal) ordinate. But it must be remembered

that in the two cases the same position of gate does not imply the same *time* of passage from the beginning. To show the contrast between the two cases more strikingly, *Fig. 3* has been constructed by plotting as ordinates, to *times* as abscissæ, the values of the pipe velocities and pressure heads. Here we can compare these values at corresponding instants of time, *i. e.*, in the same vertical. It is now quite apparent that the average ordinate of pressure curve II is probably equal to that of pressure curve I (left



The lower figured values of x are for curves II.

FIG. 3.

unfinished in the figure; it intersects the vertical $V\,b$ in a point T more than twice as far above $O\,V$ as e). The more rapid falling off of the ordinate u in the velocity curve II than that in velocity curve I on this *time-basis* is also very evident. The corresponding values for x (different in the two cases) are figured in the diagram.

In applying the test expressed in eq. (12) to this present numerical problem, as a check on all the mathematical work involved, a planimeter was employed to determine the area of the figure $O\,.\,e\,.\,V$ (of *Fig 3*), whose ordinates are pro-

portional to $v^2 - u^2$. The number, 119,800, was obtained in this way for the value of

$$\int_0^{t_0} (v^2 - u^2)\, d\, t,$$

with the foot and second; whereas the true result should be 120,000, as in the first example under uniform closing. The discrepancy is smaller than was expected, being probably within the limit of error of the method employed.

Further study of eqs. (17), (18) and (19), for uniformly retarded closing, will doubtless show that if the time is lengthened, not only is the maximum pressure smaller, but its occurrence relatively earlier.

With the third power instead of the square in the law of closing in eq. (14), we would find a still earlier reduction of the velocity in pipe, with consequently a still smaller maximum of pressure. Of course we assume throughout the whole paper that the pipe itself is fixed, so that the water finds no relief in displacing it lengthwise, and that the yielding of the pipe material is insignificant. An interesting matter for investigation would be the law of closing necessary to make the pressure nearly uniform throughout. From what precedes it is already sufficiently apparent that a relatively slow motion of gate near the *end* of the closing is quite essential to prevent a large maximum pressure.

Fig. 4 has been prepared with a view to showing the position of the lower edge of a valve gate for different values of x when the pipe is cylindrical, and the lower edge of the gate semi-circular in form (having the same radius as the internal section of pipe). In the construction of the diagram use has been made of the table given by Weisbach (see foot of p. 900, Coxe's translation of vol. i, first inverting the order of the numbers in the upper line to correct an evident misprint), for the relative area of opening under the gate at different stages of its progress.

First, if the closing is uniform we have to do with the right line $A \,..\, V$. As before $O \,..\, V$ represents the whole time t_0. The lower edge of the gate is to descend from A,

along the axis $A \ldots O$, during the closing. If there were no contraction and the pipe rectangular in section with width perpendicular to the paper, at the end of the time $t = O \ldots b^{IV}$ we would find the edge of gate at b', horizontally opposite the point b, the intersection of the ordinate through b^{IV} and the right line $A \ldots V$; for $O\ b' =$ the corresponding x in

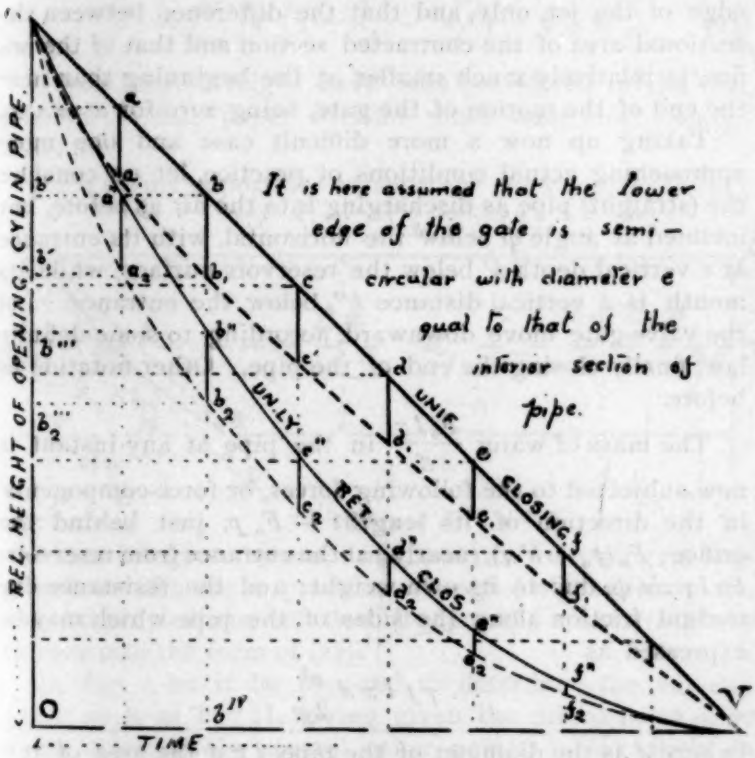

REL. HEIGHT OF OPENING; CYLIN. PIPE.
It is here assumed that the lower edge of the gate is semi-circular with diameter equal to that of the interior section of pipe.
UNIF.
CLOSING
UNIF. RET. CLOS.
O
TIME
V

FIG. 4.

such a case. But with a cylindrical pipe, still ignoring contraction, the edge of gate should at this instant be at b', by projecting b, instead of b upon $A \ldots O$; while if contraction is considered its position should be about half-way between b_1' and b'. And similarly for other values of t, as regards uniform closing utilizing the curve $A\ a_1\ b_1\ c_1 \ldots\ldots V$.

In like manner, if the closing is uniformly retarded, we

make use of the parabola $A\ a''\ b''\ \ldots\ldots\ V$, and the dotted curve below it, assigning a point about half-way between the two curves, in each vertical, as the necessary position of the gate for the assigned time, with a pipe and gate as described, thus making allowance for contraction. This latter allowance will, it is thought, be justified by a consideration of the fact that contraction occurs on the upper edge of the jet, only, and that the difference between the sectional area of the contracted section and that of the orifice, is relatively much smaller at the beginning than near the end of the motion of the gate, being zero for $x = 1{\cdot}00$.

Taking up now a more difficult case and one more approaching actual conditions of practice, let us consider the (straight) pipe as discharging into the air as before, but inclined at angle ϕ below the horizontal, with its entrance at a vertical depth h' below the reservoir surface, while its mouth is a vertical distance h'' below the entrance. Let the valve-gate move downward, according to some definite law, finally closing the end of the pipe. Other notation as before.

The mass of water $\frac{F_0\, l\, \gamma}{g}$ in the pipe at any instant is now subjected to the following forces, or force-components, in the direction of its length: $-F_0\, p$, just behind the orifice; $F_0(p_a + h'\gamma)$, (nearly,) at the entrance from reservoir; $F_0\, l\, \gamma\ sin\ \phi$, due to its own weight; and the resistance due to fluid friction along the sides of the pipe which may be expressed as

$$\gamma\, f\, l\, \pi\, d\, \frac{u^2}{2g}$$

[where d is the diameter of the pipe, $l\, \pi\, d$ the area of rubbing surface, and f a coefficient (abstract number) = about 0·05, which for present purposes may be taken as a constant; f is the m of Mr. J. T. Fanning's work on *Hydraulic Engineering*]; whence we have, from *Force = mass × acceleration*,

$$-F_0(p - p_a) + F_0 h'\gamma + F_0 \gamma\, l\ sin\ \phi - \gamma\, f\, l\, \pi\, d\, \frac{u^2}{2g} = \frac{F_0\, l\, \gamma}{g} \cdot \frac{du}{dt}. \qquad (20)$$

But $l \sin \phi = h''$, $F_0 = \frac{1}{4} \pi d^2$, and $h' + h''$ may be denoted by h; whence, with the aid of eq. (3),

$$-\frac{v^2 - u^2}{2g} + h - 4f \frac{l}{d} \cdot \frac{u^2}{2g} = \frac{l}{g} \cdot \frac{du}{dt}. \qquad (21)$$

By dividing by dx and transforming, remembering also that $v = u + x$, (21) may be put into the form—

$$\frac{du}{dx} = \frac{dt}{dx}\left[u^2\left(1 - \frac{1}{x^2} - \frac{4fl}{d}\right) + 2gh\right]\frac{1}{2l} \qquad (22)$$

(Fluid friction might have been considered in the first problem of this paper without much additional complication.)

As it seems impossible to separate the variables in (21),

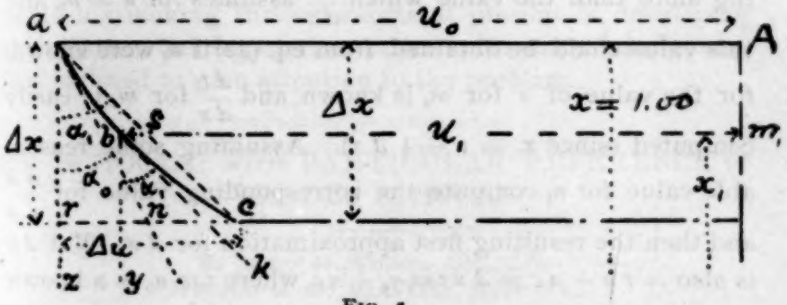


FIG. 5.

and thus integrate by exact methods, the following is suggested as offering a practical, though only approximate, and rather tedious, solution [to present which (21) was thrown into the form of (22)].

In *Fig. 2*, let it be required to determine the velocity curve, such as I or II, having given the initial point a, by fixing successively several other points, taking them in order from a downwards. First, *Fig. 5* (as a graphic representation for guiding the computations), of this curve we have given the initial point a, i. e., we know the abscissa u_0, whose $x = 1{\cdot}00$, and we also have eq. (22), and some assumed relation between x and t (constituting the law of closing) from which the value of $\frac{dt}{dx}$ can be obtained for any assigned value of x. We may, therefore, proceed thus:

Assume a small decrement Δx for x (say, $\Delta x =$ about 0·10). The corresponding decrement for u, viz: Δu, we wish to compute by successive approximations. When Δu is found, the point c of the velocity curve will be located. Conceive the short arc $a \ldots c$ to be drawn, as also its chord $a \ldots c$, and the tangent $a \ldots n$ at a; also the tangent $b \ldots k$ at the point b, which is determined by drawing $m_1 \ldots s \ldots b$ parallel to $A \ldots a$ and bisecting Δx.

Considering $a \ldots c$ to be a short arc of a parabola whose axis is parallel to $A \ldots a$, $b \ldots k$ will be parallel to the chord $a \ldots c$ (so that angle $k\,b\,y =$ angle $c\,a\,r = \alpha$), and $n \ldots c$ will be equal to $4\,\overline{b\,s}$.

Now $\Delta u = \Delta x . \tan \alpha = \Delta x \tan k.b.y$; but $\tan \alpha$, is nothing more than the value which $\frac{du}{dx}$ assumes for $u = u_1$, and this value could be obtained from eq. (22) if u_1 were known, for the value of x for m_1 is known, and $\frac{dt}{dx}$ for m_1 is easily computed (since $x_1 = 1 - \frac{1}{2}\Delta x$). Assuming some reasonable value for u_1 compute the corresponding value for $\frac{du}{dx}$ and then the resulting first approximation for Δu. But Δu is also $= \overline{r\,n} + \overline{n\,c} = \Delta x \tan \alpha_0 + \overline{n\,c}$, where $\tan \alpha_0$ is a known quantity being easily found as the value of $\frac{du}{dx}$ when $u =$ the known u_0, while $\overline{n\,c}$ should be $= 4\,\overline{b\,s}$ (on the parabola basis). Hence, if $\overline{n\,c}$, $= \Delta u - \Delta x \tan \alpha_0$, does not prove to be very nearly $=$ to four times $\overline{b\,s}$ (*i. e.*, the $\overline{b\,s}$ based upon the assumed u_1 and the first approximation to Δu, viz:

$$\overline{b\,s} = u_1 - \frac{1}{2}(u_n + u_0 - \Delta u), \qquad (23)$$

another trial must be made, and so on, until the quantities are adjusted as desired.

With c as a new starting point another short arc may be added, and still others, until the axis $O \ldots M$ (of *Fig.* 2) is reached. The curve should strike the point O on this axis, and if such is not far from the case with the trial curve, corrections can be made to secure such a result. This is, of

course, a further check on the work. With the velocity curve plotted, though only approximately, computations for the pressure are easily made at any point, and the maximum pressure found.

When the pressure in the pipe just below the gate is not one atmosphere but variable (perhaps falling below one atmosphere where the pipe falls continuously down-stream for a considerable distance), a new and variable quantity of uncertain determination enters into the analysis. However, by a knowledge of all the attendant conditions, a reasonable assumption may be made of the variation of this pressure, and an approximate velocity curve determined by the method just indicated.

The writer regrets that pressure of regular duties prevents his making further efforts at present in developing this matter, but hopes that others with more leisure may feel inclined to give attention to the problem.

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

By JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 328.*]

GREAT BRITAIN.

Much has been done in Great Britain to foster and promote education in the sciences and arts, and some of the applied science schools, as well as the art schools, of which South Kensington appears to be the head, are models in their particular departments.

What we mean by "Industrial or Trades School," however, do not appear to exist to so great extent or in nearly so advanced a condition as found in France. The term "Industrial," as used in England, refers to "Ragged Schools," schools for "street arabs," an entirely different class from these we are considering.

A royal commission was appointed by Parliament in 1872 for the purpose of making investigations on the subject of schools for technical instruction. A few extracts from the evidence given before this commission by Mr. Thomas Comber, for fifteen years head master of the Bristol trade schools, may be interesting.

Mr. Comber stated that evening classes had been held for teaching science to the operative classes for eleven years. He had occupied lectureships in chemistry to societies and local associations in Bristol; also as head master of the Bristol trade schools he had taught mathematics, with its application to mechanics and mechanism, and descriptive geometry, with its applications to machine drawing and building construction, or to wood artificer's drawing. In addition he had taught chemistry, both inorganic and organic, and experimental physics, including electricity, magnetism, acoustics, light and heat. Up to the time of his statement, however, nothing systematic had been done in reference to practical instruction and manipulation. A considerable number of the boys were employed occasionally in the preparation of experiments, but systematic instruction was confined, so far as day-schools were concerned, to several boys who had been withdrawn from schools and apprenticed to chemists. The school had all the apparatus necessary for illustration and instruction in chemistry and experimental physics. Youths receiving education at the Bristol school, commonly devoted themselves to manufacturing and mechanical trades, chiefly mechanical. There was no system by which a boy could go into a building or mechanical trade for a time, after being at the school, get mechanical dexterity and then come back again. The boys leave the day-school at fourteen or fifteen years of age, but continue their education in the night-schools.

They had expected to take only boys who had passed the elementary schools, but were obliged to form an elementary school for themselves. There were 160 boys, of which 100 were not learning science at all. Boys were received in the elementary school at ten to eleven years of

age; they get into the science school at twelve and remain until fifteen years of age. Masters refuse to receive boys for apprenticeship over fifteen years of age, and for that reason the boys do not remain longer. The results of the school, so far as could be seen, were good, but it had not been established over fifteen years and it was hardly time to see the results as yet. It was proposed to introduce lectures in night classes, on practical subjects, practical construction, etc.

Mr. Comber did not think that boys should be taken into science schools earlier than twelve years of age.

This evidence and much of corresponding kind was given some years ago, but that very little change has since been made in such science or trades schools, unless only recently, is shown by reference to the reports of a later parliamentary commission on technical instruction appointed in August, 1881.

The commission states in its first report that after an examination of the French schools it is not sufficiently convinced of the advantages of apprenticeship schools for training ordinary workmen, like those of la Villette and Havre, as compared with the great cost of their establishment and maintenance, to warrant a recommendation of their introduction into Great Britain until a more prolonged trial has been had abroad.

What the same commission might say now, seven years later, it is difficult to tell, but it is probable that the old apprenticeship system has not yet reached so low an ebb in England as it has in France, and that the necessity of a substitute is not so apparent.

The British Parliament grants annually a sum of money for public education in England and Wales, to be administered by the educational department. The object of this grant is to aid in maintaining, first, public elementary schools, and, second, training-colleges for teachers.

An elementary school is a school or department of a school in which elementary education is the principal part of the course, and no school or department is included in this class where the ordinary payment for each scholar

exceeds nine pence per week, exclusive of payments for books and other school articles. A *public* elementary school is one that is and must be conducted in accordance with the following regulations:

(1) "It shall not be required as a condition of any child being admitted into or continuing in the school that he shall attend or abstain from attending any Sunday-school or any place of religious worship, or that he shall attend any religious observance or any instruction in religious subjects in the school or elsewhere, from which observance or instruction he may be withdrawn by his parent, or that he shall, if withdrawn by his parent, attend the school on any day exclusively set apart for religious observance by the religious body to which his parent belongs.

(2) "The time or times during which any religious observance is practised or instruction in religious subjects is given at any meeting of the school, shall be either at the beginning or at the end of such meeting, and shall be inserted in a time-table to be approved by the Education Department, and to be kept permanently and conspicuously affixed in every school-room; and any scholar may be withdrawn by his parent from such observance or instruction, without forfeiting any of the other benefits of the school.

(3) "The school shall be open at all times to the inspection of any of Her Majesty's Inspectors, so, however, that it shall be no part of the duties of such inspector to inquire into any instruction in religious subjects given at such school, or to examine any scholar therein in religious knowledge or in any religious subject or book.

(4) "The school shall be conducted in accordance with the conditions required to be fulfilled by an elementary school, in order to obtain an annual parliamentary grant.

Inspectors are appointed by Her Majesty on the recommendation of the Department, the term inspector covering all assistants, acting inspectors, etc.

The term "managers" includes all those who have the management of any elementary school, whether the legal interest of the school is vested in them or not; the Department holds the managers responsible for the conduct of

their schools; their maintenance in efficiency; the provision of all needful furniture, books and apparatus and in particular of suitable registers; a portfolio to contain official letters; the code and revised instructions for each year, and a diary or log-book. In the latter are to be entered, from time to time, by the principal teacher, such events as the introduction of new books and apparatus, courses of instruction, plans of lessons approved by inspectors, visits of managers, absence, illness, etc., but no reflections or opinions of a general character. Children engaged in work may be entered as "half-time" scholars.

An "attendance" means an attendance at secular instruction during one and one-half hours in a day-school for infants, and two hours for older children, or for half-time scholars one hour and twenty minutes, so that two consecutive hours make an attendance and a half. No attendance for a half-time scholar of less than two consecutive hours is recognized.

For an evening scholar, one hour counts as an attendance. An "attendance" is not recognized if a scholar withdraws before the time constituting an attendance is completed. The minimum time counting an attendance may include an interval for recreation of not over fifteen minutes for a meeting of three hours or not over ten minutes for a shorter meeting. Military drill can be given to boys under a competent instructor for not more than two hours in any week, or forty hours in a school year, and lessons in practical cookery to girls, where special and appropriate provision is made for it, for not more than forty hours in a school year, and may be reckoned as instruction. Scholars may attend science classes at any place approved by the inspector.

Attendance is not recognized for a scholar under three years of age, and for one who has passed in the seventh standard of education (the highest standard of education for elementary subjects), unless he is permitted by the inspector to have a re-examination in that standard. Neither is any standard recognized for any scholar in an evening-school under fourteen or over twenty-one, but children under fourteen, deemed by the Department as exempt from the

legal obligation to attend school, are recognized as scholars in an evening-school.

The subjects of instruction for which grants may be made, are the following:

Obligatory subjects:

Reading,
Writing,
Arithmetic, } called elementary subjects.
Needle-work (for girls in day-schools).

Optional subjects:

(I) Taken by classes throughout the school.

Singing,
English,
Geography,
Elementary science, } called class subjects.
History,

(II) Taken by individual children in the upper classes of the school.

Algebra,
Euclid and mensuration,
Mechanics,
Chemistry,
Physics,
Animal physiology, } called specific subjects.
Botany,
Principles of agriculture,
Latin,
French,
Domestic economy,

(III) Taken by boys in infant schools or classes.

Drawing.

Other subjects may be taken as specific subjects if authorized by the Department, a graduated scheme of teaching them to be approved by the inspector. Instruc-

tions may be given in other secular subjects and in religious subjects, but no grant is made for such.

Inspectors visit the schools in order to examine whether the conditions of the annual grants have been fulfilled and to report to the Department.

There are a number of rules and regulations in reference to inspectors and their visits, not important to note in the present report. The inspector arranges for annual visits, examinations, etc., but may visit a school at any other time without notice. The managers of any public elementary school are required to admit to the annual examination, and the inspector is required to examine, for a certificate of proficiency, any child over ten years of age and under fourteen, whether a scholar in the school or not, who applies to be examined.

The teachers recognized by the Department are—

(*a*) Pupil teachers;
(*b*) Assistant teachers;
(*c*) Provisionally certificated teachers;
(*d*) Certificated teachers;
(*e*) Evening-school teachers.

Lay persons alone are recognized as teachers in day-schools.

A pupil-teacher is a boy or girl engaged by the managers to teach during school hours under the superintendence of the principal teacher and also receiving instruction. The managers must see that the pupil-teacher is properly instructed, and if the Department is satisfied that this duty is neglected it may refuse to recognize such pupil-teacher as a member of the staff under such managers. As a rule, the pupil-teacher must be of the same sex as the principal. A pupil-teacher must not be less than fourteen years of age, must have received instruction in two of the class subjects for the two years immediately preceding the engagement, and must have passed an examination according to a certain specified standard.

There are various rules governing pupil-teachers not important here. The term of engagement is ordinarily

four years, but it may be less, or may extend to five years. At the end of the engagement, the pupil-teachers are free to choose employment. If they wish to continue as elementary school-teachers, they may, under certain conditions, become either students in training-colleges, assistant teachers or provisionally certificated teachers. There are residential and day training-colleges, and there is an annual examination for admission into such colleges, the candidates being selected and admitted to the examination by the authorities of each college on their own responsibility, subject to no other conditions than that—

(1) Being, or not having been, pupil-teachers, they are more than eighteen years of age on the first of January next following the date of examination;

(2) That they have passed a thoroughly satisfactory examination in all the subjects specified in a certain specified standard. If pupil-teachers fail in this examination, they may, with the consent of the Department, be re-examined once.

The candidates who pass the examinations are arranged in three classes in order of merit.

(1) Assistant teachers in public elementary schools.

(2) Provisionally certificated teachers in charge of small schools.

(3) Certificated teachers.

Graduates of any university in the United Kingdom, women over eighteen years of age who have passed university examinations recognized by the Department, may also be recognized as assistant teachers.

Certificated teachers must be examined and must undergo probation by actual service in school. Examinations are held annually in December at each training-college and at such other points as may be fixed.

The examination for certificates is open to students who have resided, or been recognized as day students, for at least one year in any training-college under inspection, or to those who, being upwards of twenty years of age, have either been employed for not less than two years as provisionally certificated teachers; or have served as assistant

teachers for at least twelve months in inspected schools under certificated teachers, and have obtained a favorable report from an inspector on their skill in teaching, reading and recitation.

The managers and inspectors must make annual reports under certain instructions.

Any person over eighteen years of age, approved by the inspector, can be made a teacher of an evening-school, and such teachers need not be lay persons.

The recognized teachers in any school form the school staff.

There are various rules governing vacancies, etc.

Annual grants are given to a school, from the appropriation by Parliament, on certain conditions being fulfilled.

It must be conducted as a public elementary school.

No child may be refused admission on other than reasonable grounds.

The time-table must be approved for the Department by the inspector.

The school must not be unnecessary.

It must not be conducted for private profit.

The principal teacher must be certificated (certain exceptions).

A day-school must have at least 400 meetings in the year, and a night-school at least forty-five (certain exceptions).

The school must have been seen and reported on by an inspector, unless some unforeseen cause has made such visit and report impossible.

The Department must be satisfied, (1) That the school premises are healthy, well lighted, warmed, drained and ventilated, properly furnished and supplied with suitable offices and contain sufficient accommodation for the scholars attending the school. (The school premises should be constructed in general conformity with the rules for planning and fitting up public elementary schools. In any case an endeavor must be made to secure at least 100 cubic feet of internal space, and ten square feet of internal floor area, for each unit of average attendance.) (2) That the girls in a day-

school are taught plain needle-work and cutting-out as part of the ordinary course of instruction. (3) That the admission and daily attendance are carefully registered by or under the supervision of the principal teacher and periodically verified by the managers; that accounts of the income and expenditure are accurately kept and audited; that all statistical returns and certificates of character are such that they may be accepted as trustworthy and that the school is not conducted in violation of the provisions of any statute. (4) That the principal teacher is not allowed to undertake duties not connected with the school, which may occupy any part whatever of the school-hours, or of the time appointed for the special instruction of pupil-teachers. (5) That the school is conducted with efficiency.

All returns called for by the Department or Parliament must be duly made.

The managers must at once comply with any notice of the sanitary authority of the district as to closing school if necessary, or excluding any scholars from attendance, to avoid spread of disease. If they consider the order unreasonable they may appeal to the Department after complying with the request.

The income of the school must be applied only for the purpose of public elementary schools. Part of the salary of an organizing teacher can be included in the expenses, or a teacher of drill, cooking or other special subjects, but not expenditure for Sunday-schools, school treats, or any outlay on the premises (except for ordinary repairs), or for other purposes not recognized by the Department as educational.

Grants are made to infant schools and classes under certain conditions, among which there is a grant for needle-work, not only for the girls, but for boys also, if they are satisfactorily taught. The boys may be taught drawing instead of needle-work. There is also in these schools a grant for singing if the scholars are taught to sing by note, and a grant of less amount if taught to sing by ear.

The details as to grants for the various schools for older scholars, evening-schools, etc., are not of special interest in the present inquiry, further than that grants are made for

needle-work for girls and when the inspector reports that special and appropriate provision is made for the practical teaching of cookery, by a teacher holding a certificate from some training-school of cookery recognized by the Department; a grant is made for cookery on account of any girl presented for examination in elementary subjects in certain standards, who has attended not less than forty hours during the school year at a cookery class of not more than twenty-four scholars and has spent not less than twenty hours in cooking with her own hands.

There are certain conditions attached, not important here. Grants are also made for instruction in cookery in the evening classes.

A training-school is an institution either for boarding, lodging and instructing, or for merely instructing students who intend to become certificated teachers in elementary schools, being therefore either a residental or day training-college, and the same college may include both. There must be a practising school, within a convenient distance, where the students may learn the practical part of their profession.

The conditions of examination for admission into training-colleges have already been mentioned, but the authorities may admit without examination any person who has passed the examination for the first year and who wishes to enter the college for a year's training in the course prescribed for students of the second year.

Before a candidate is admitted, the medical officer attached to the college must examine as to the state of his health and freedom from bodily infirmity, the candidate must also sign a declaration that he intends *bona fide* to adopt and follow the profession of teacher in a public elementary school or training-college, or in the army or navy, or (within Great Britain) in poor law schools, certified industrial or day-schools, or certified reformatories.

There are certain rules governing the examinations and certain grants to training-colleges which need not be noted here.

Pensions are granted to teachers, subject to certain con-

ditions, but only to those employed in that capacity at the date (May 9, 1862,) when the minutes relating to pensions were cancelled.

It would be possible to give here schedules showing:

(1) Standards of examination in the elementary subjects.

(2) Class subjects.

(3) Needle-work.

(4) Specific subjects of secular instruction.

(5) Schedule of certificates and curriculum of pupil-teachers during their engagement.

Etc., etc., but it is not considered necessary to the objects of the present paper, except for the schedule for needle-work which may be found very useful in arranging for a course of teaching in that accomplishment, and it is therefore here appended.

[*To be continued.*]

THE ELECTRICAL EXHIBITS AT THE UNIVERSAL EXPOSITION IN PARIS, 1889.

[*From the Report of Mr.* CARL HERING, *Delegate of the* INSTITUTE.]

GAS ENGINES WITH ELECTRICAL IGNITION.

The ignition of the gases in gas and petroleum engines by an electric spark appears to be coming into use more generally, judging from the large proportion of engines exhibited in which this way is preferred to the gas flame ignition. There were exhibited twenty-one different systems of gas and petroleum engines, counting the various different exhibitors of the Otto engine as one exhibit. Of these, thirteen (or sixty-two per cent.) used electrical ignition, and only eight (or thirty-eight per cent.) used the gas flame ignition.

Historical.—The following abstracts regarding the history of electrical ignition is taken from a paper of Mr. Delamere-Debouttéville, read before the Institution of Mechanical Engineers, July 3, 1889. In 1844, John Reynolds used a

platinum wire heated by means of a battery. A mechanical contact maker and breaker started and stopped the current at the proper moment. In 1850, Shepherd used an electro-magnetic generator in place of a battery. In 1857, Barsanti & Mattenni used a Bunsen battery, with a de la Rive multiplier, the sparks from which were used. In 1860, Lenoir replaced the de la Rive multiplier by a Ruhmkorff induction coil. The primary current passed continually, and the secondary was closed when the spark was required. There was difficulty in timing the spark exactly.

General.—The heated platinum wire is apt to become cooled at the moment of the passage of the gases, and it cannot be timed sharply, besides requiring considerable battery power. It therefore seems to be abandoned. All the engines exhibited used the spark. The chief advantages of the spark over the gas flame, appear to be, its very high temperature, which is of importance, especially when poor gases are used; it is independent of cold or moist air; it reduces the temperature of the valve chest and parts, and thereby facilitates lubrication of those parts and does away with incrustations there; in some of the systems it can be very definitely timed, which is claimed to be very important as there is said to be a considerable difference in the power if the time of ignition varies one-twentieth of a second. The disadvantages of using electricity in place of the gas flame depend upon the particular system used; in general, it introduces something with which the ordinary mechanic is not familiar.

The systems exhibited are here divided for convenience into four classes. All in common use this ignition only, having no means for gas ignition, showing that they can rely entirely on the spark. In all but one, the spark is made to pass in the cylinder, in the other it is in a special chamber. The insulation of the parts entering the cylinder are variously of porcelain, plaster-of-paris, or asbestos, in order to stand the heat and the mechanical pressure of the explosions.

First System.—In the first system, a battery, generally two or three large Bunsen or bichromate cells, is used with an

ordinary Ruhmkorff induction coil having a simple hammer vibrator; the vibrator acts all the time while the engine is running, and the spark of the secondary coil is operated by various means. In all of these the spark passes between two *fixed* points in the cylinder. The advantages of this system over some of the others is that there are no moving parts entering the cylinder; that there are numerous sparks generated instead of a single one, as in some of the others; and that the spark can be well timed. The disadvantage is that the vibrator acts all the time, which is bad for the contacts of the vibrator, and consumes battery power continually.

Details.—In the engine exhibited by E. Roger (French Section) the secondary circuit is normally open at a sort of switch outside of the cylinder, which is operated by the moving parts of the engine, and is closed the instant the spark is required for the explosion. When the switch is closed the only break in the secondary circuit is in the cylinder, where the sparks are therefore produced. It is evident that no premature explosions can take place.

In the engines of Louis Charon and those of Solomon Frères & Tenting (French Section) the secondary circuit is continually short circuited outside of the cylinder, except the instant when the spark is required. Premature explosions cannot take place unless this short circuiting switch is exceedingly dirty. They used two large cells.

Those of Thomas Powell (French Section) differ essentially from the others, in that the spark passes continually in a spark chamber, which is closed by the slide valve. When ignition is to take place, a port in the slide valve makes this spark chamber communicate with the cylinder, thus igniting the gases. The length of the spark is 1·5 mm., or about one-sixteenth inch. They claim that the instant of ignition can be more accurately and definitely timed by these ports in the slide valve. There is probably more possibility of premature explosions, as in the flame ignition engines, causing it to "sneeze." They use only one cell of two carbon plates in bichromate solution, the zinc being in sulphuric acid in a porous cup.

Second System.—In the second system a battery and induction coil are used as before, but the primary circuit, instead of the secondary, is closed when the spark is required. The vibrator, therefore, acts only while the primary circuit is closed, thus economizing battery power. It has the same advantages as the first system, except that the spark is not so definitely timed, and is not so sure, as it is necessary that the vibrator starts itself and responds promptly; to do this it must be well adjusted, and its contact must be very clean; it is difficult, if at all possible, to clean it while running.

To this class belong the engines of the Société des Moteurs à Gaz Français, A. F. Noel (French section), and of the Société Anonyme des Moteurs Inexplosibles au Petrole et au Gaz (Belgian section). In these the primary circuit is operated by a contact piece on the shaft or other moving part, and a brush sliding thereon, usually made adjustable in order to time the spark. The one exhibited by Rouart Frères & Cie (French section), was a double-cylinder engine, and in addition to the above there was a second contact piece on the revolving shaft connected to the secondary circuit, and having two brushes, the object of which was to switch this secondary circuit alternately to each of the two cylinders. They used only two large one gallon bichromate cells. The frame of the engine was used as a ground return circuit for both the primary and the secondary currents.

Third System.—In the third system a magneto machine is used to generate the spark without an induction coil. The armature of the magneto, usually a simple Siemens H armature, is kept from revolving by a strong spiral spring. For each explosion it is revolved on its shaft through 90° against this spring and allowed to snap back into its normal position, during which rapid return motion it generates a momentary current. An instant after the armature is released, and at the moment when its current is a maximum, the circuit is broken in the cylinder, producing there a single bright spark. The advantages are that no battery is required, there is no coil with a vibrator to keep in order, and it is always ready to start; as the high rate of rotation necessary to generate the current is produced by a snap

movement, no great speed of the engine is required at starting, as would be the case if a dynamo was used in place of a magneto. A disadvantage is that only one spark is produced in place of a number of them as in the other systems, but as it is a much more powerful spark, and quite positive, it does not appear to be an objection. In this system there must be moving parts entering the cylinder to break the circuit there.

The engines of Gotendorf & Cie, and of E. Delahaye (French section) were of this class. In the latter, the exact time of the spark may be adjusted by a cam movement. The engine of W. C. Horne (British section) also belongs to this class, it differs from the other two in that the H armature is normally in the stable position into which the magnets would pull it, the spring assisting it to return to this position, while in the other two the normal position is the unstable position, in which it is held against the magnetic pull by the spring, which must, therefore, necessarily be much stronger. The spark is produced between two steel springs in the cylinder, operated by means of a rod passing through a stuffing-box. This rod has a rotary motion instead of a longitudinal one, thereby facilitating the construction of the fire-proof stuffing-box.

Fourth System.—In the fourth system a dynamo or magneto is turning all the time, generating the current which is broken in the cylinder directly without a Ruhmkorff coil. The disadvantages of this system are that in starting the engine, sufficient speed must be produced by hand before the dynamo will generate sufficient current to produce a spark.

In the engine of E. Durand (French section), a small simple magneto is used generating an alternating current. Both wires are insulated, that is, the frame of the engine is not in circuit. The circuit is broken in the cylinder by a revolving rod, as in the engine of Horne. No self-induction coil is used.

In the Baldwin Gas Engine (United States section) the current is generated by a small shunt-wound dynamo of about one-eighth horse-power. It is driven directly from

the fly-wheel by a friction pulley, the pressure being produced by its own weight. There are two friction pulleys of different sizes, the smaller one, for high speed, is used only for starting. There is a self-induction or spark coil in circuit, and the circuit is closed except when the spark is required. The breaking of the circuit is operated by an insulated pin passing into the cylinder and having a longitudinal motion. It is difficult in this arrangement to keep the contacts in the cylinder clean, especially as the tendency of this particular construction is to destroy its own contact.

THE THORNE TYPE-SETTING MACHINE.

[*Report of the Committee on Science and the Arts.*]

[No. 1,498.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 2, 1890.

THE Sub-Committee to whom was referred for examination and report,

THE THORNE TYPE-SETTING AND DISTRIBUTING MACHINE,

respectively

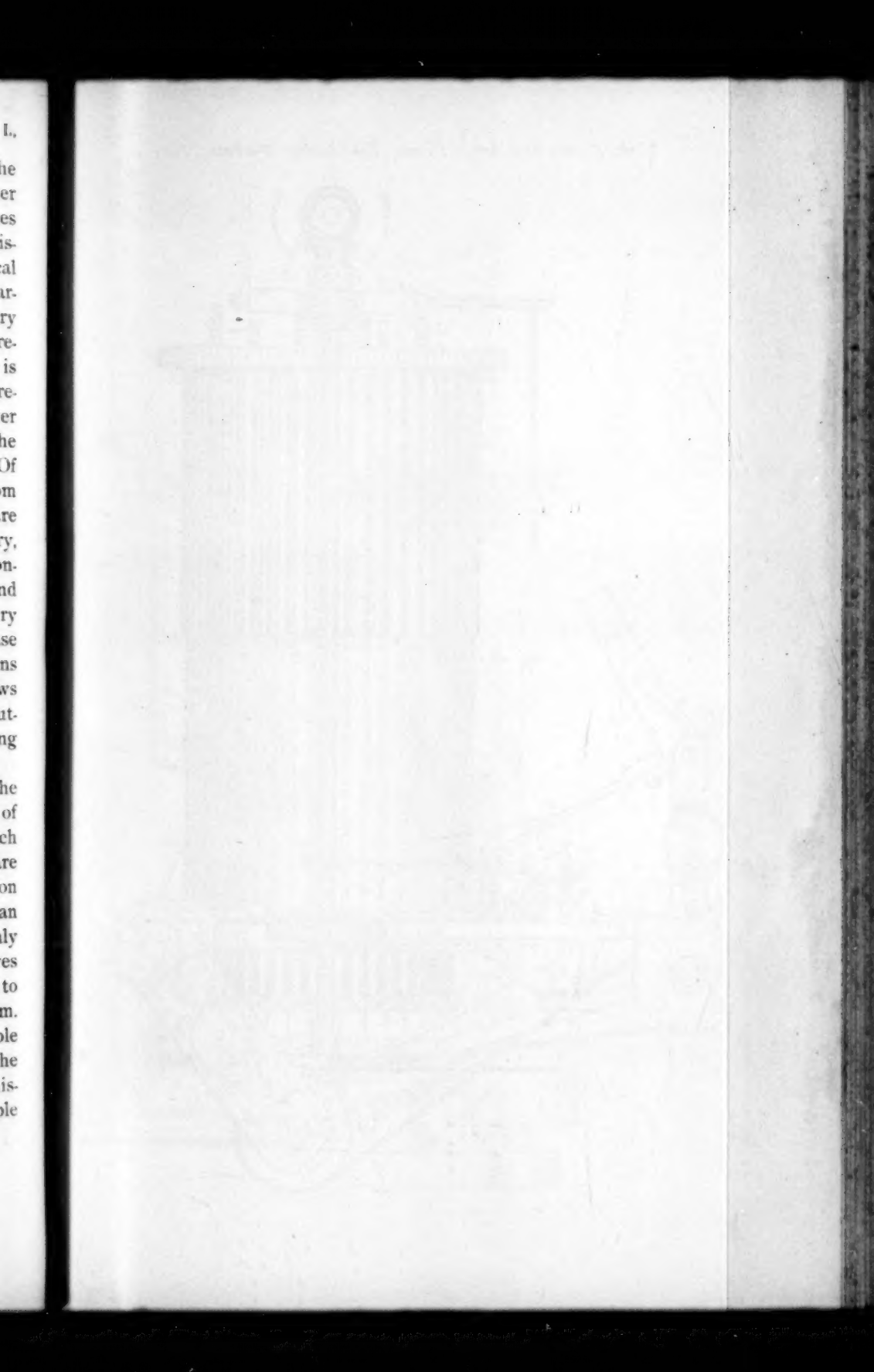
Report that: They have examined the machine in operation, they have visited the factory in Hartford, and observed carefully the construction and methods practised for securing accuracy and perfection of workmanship, and have also examined the Letters-Patent of the United States describing said invention, and find as follows:

That the machine is designed for the setting of type, and the distribution of type after it has been used from forms into the machine for repeated use. A general description of the machine which is shown in the accompanying illustrations is as follows: We quote this from the description of the manufacturer as being remarkably exact for a terse description, and as preliminary to going more fully into the detail of its construction.

As will be seen on reference to the general view, the two principal features of the Thorne type-setting and distributing

machine are a key-board and two vertical cylinders having the same axis, the upper cylinder resting upon a collar on the lower one. Both cylinders are cut with a number of vertical grooves of such a form as to receive the type, which is to be first distributed and then reset. There are ninety of these vertical grooves in each of the cylinders, sufficient to contain all characters and kinds of characters that are wanted for ordinary purposes. The key-board carries a number of keys corresponding to that of the grooves, and when the machine is in operation, whatever key is depressed the letter corresponding to it is ejected, from its proper groove in the lower cylinder, upon a circular and revolving table, which has the same axis as the cylinder, but is of larger diameter. Of course, quite a number of types may thus be ejected from the grooves in each revolution of the disc, and all are brought round in their proper order to a point of delivery, where they are conveyed by a travelling band and fed continuously to a setting-stick, in front of the key-board and thence to a galley. Here, any justifying that is necessary is done by a second operator, who sits opposite a small case containing spaces, quads, and so forth. Proof corrections are, of course, done in the ordinary way. The general views exhibit the machine in service, and the mechanism for putting the type-setting machinery in motion, and for causing the distributing cylinder to revolve.

The control of the types is effected by forming on the side of each character recesses something like the wards of a key, the arrangement, of course, being different for each different character. The grooves in the lower cylinder are provided with projections corresponding to these grooves on the types, so that no type will fall into any groove other than that for which it is intended. This arrangement applies only to the lower cylinder which does not revolve. The grooves in the upper or distributing cylinder are large enough to receive all the types indifferently that are fed into them. The work of distribution is effected as follows: A suitable attachment to the side of the upper cylinder, enables the operator to place the galley containing the type to be distributed in contact with the cylinder, and by a very simple



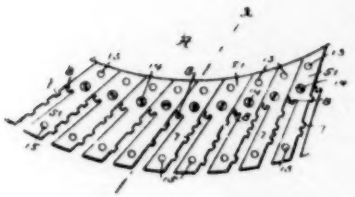
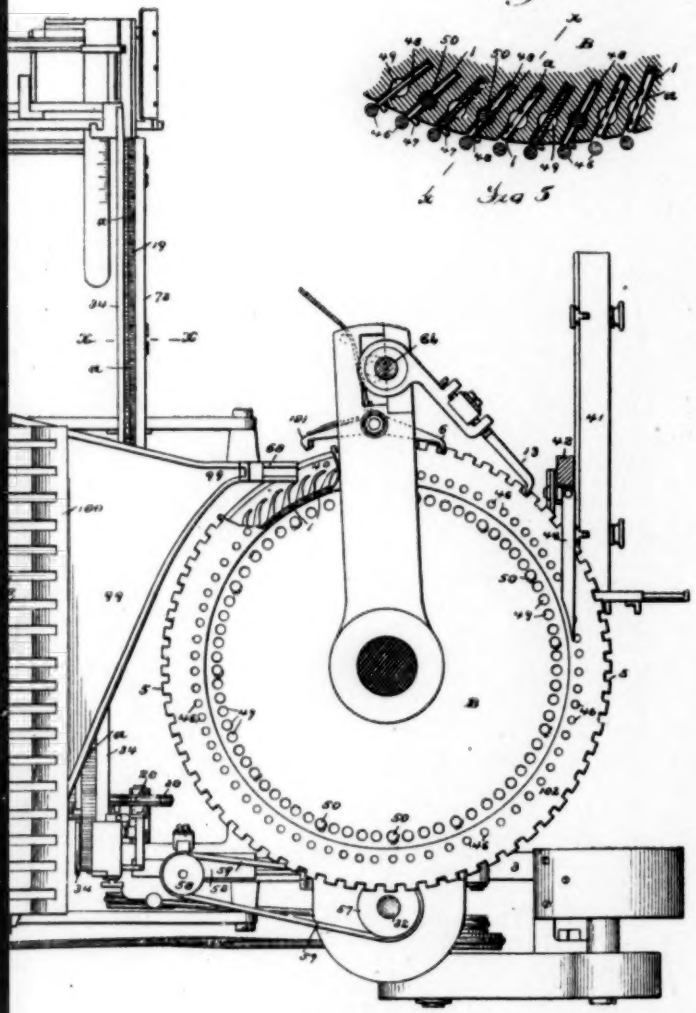


Fig 7

Fig 4.

Fig 5



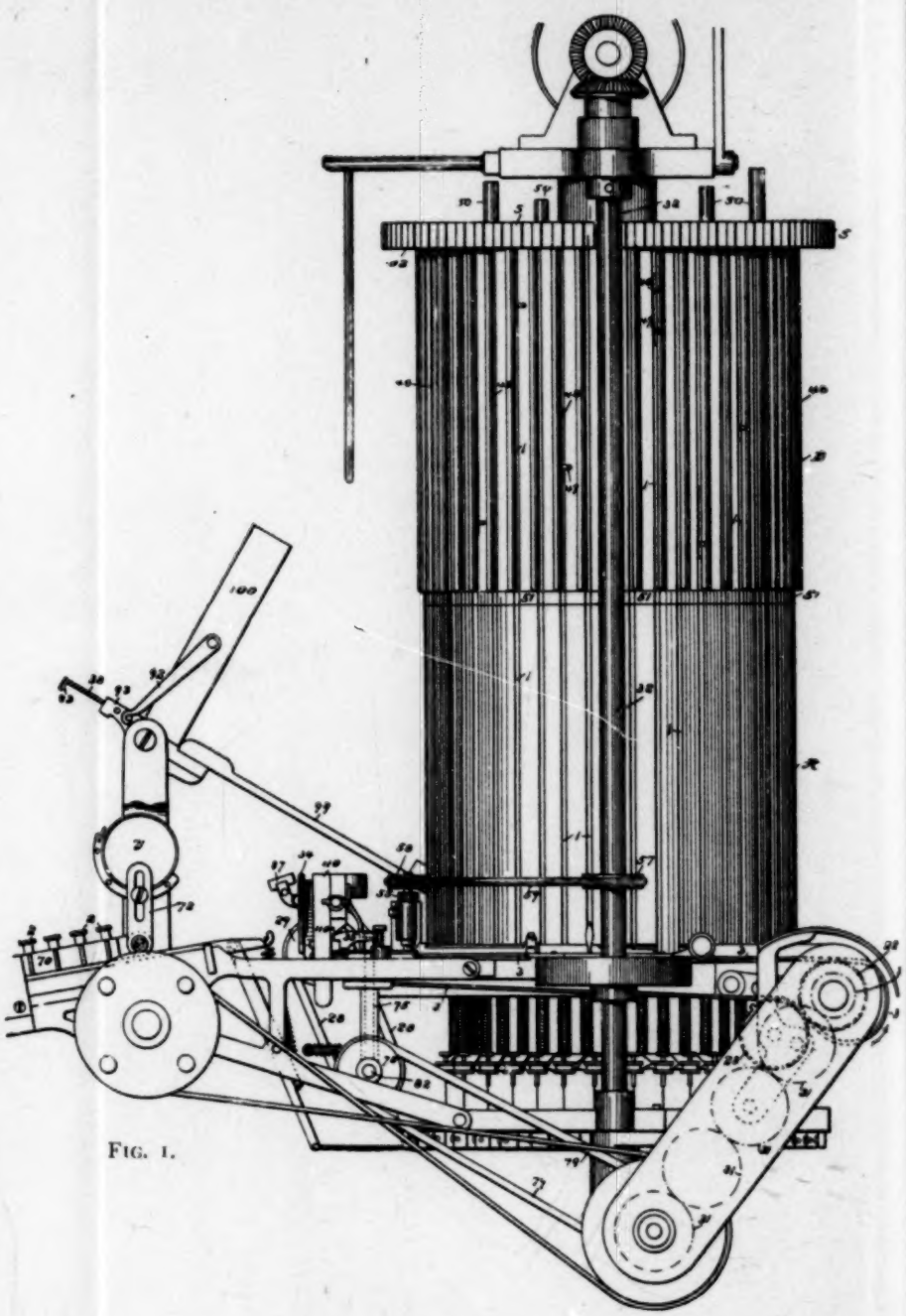


FIG. 1.

device, line after line of type is fed into the cylinder until, if desired, every groove is nearly filled, and the upper cylinder is caused to revolve upon the lower one, with which it is in contact. As the columns of mixed type pass over the heads of the shaped grooves of the lower cylinder, letter by letter falls into its proper groove, as soon as the nicks in the types find their corresponding wards. In this way, and at a speed depending on the rate at which the revolving table is driven, the types are all under perfect control of the compositor.

The invention is the subject of the following Letters-Patent of the United States.

No. 232,157, dated September 14, 1880, entitled type-setting and distributing machine.

No. 283,934, dated August 28, 1883, same title.

No. 372,186, dated October 25, 1887, same title.

No. 372,187, dated October 25, 1887, same title.

No. 387,546, dated August 7, 1888, justifying apparatus.

No. 388,088, dated August 21, 1888, justifying apparatus.

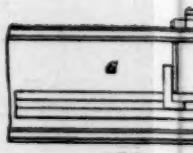
R. W. Nelson, No. 402,537, April 30, 1889, type-setting machine.

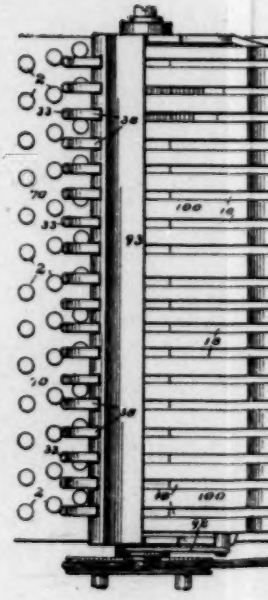
R. W. Nelson, No. 417,074, December 10, 1889, type-setting machine.

T. J. Lumis, No. 417,057, December 10, 1889, type-setting machine.

The general construction of the machine is shown in the perspective drawing. For the description of its details, the drawings of Letters-Patent 372,187 are referred to in preference to those of the earlier patents because the features set forth in the earlier stages of the invention are therein reproduced, and the relation of the later improvements to each other more clearly appears.

In *Fig. 1* of this patent (372,187) a side elevation is shown, the lower half of the fluted or channelled cylinder is stationary and forms the type case *A*, of the machine, and the upper half which forms a distributing case *B*, rotates upon it with an intermittent step-by-step motion, the extent of which motion is exactly equal to the central distance between the adjacent flutes or channels.





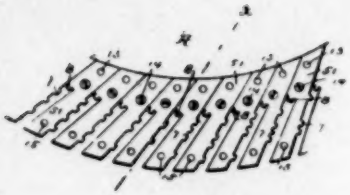
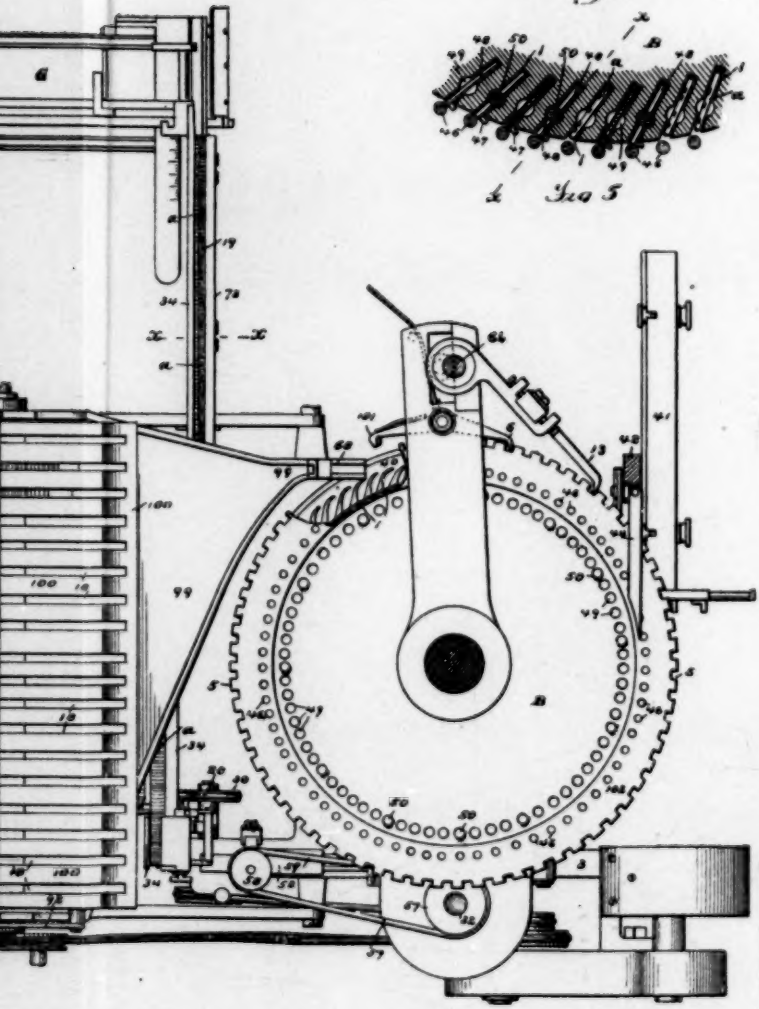


Fig 7

Fig 4.

Fig 5



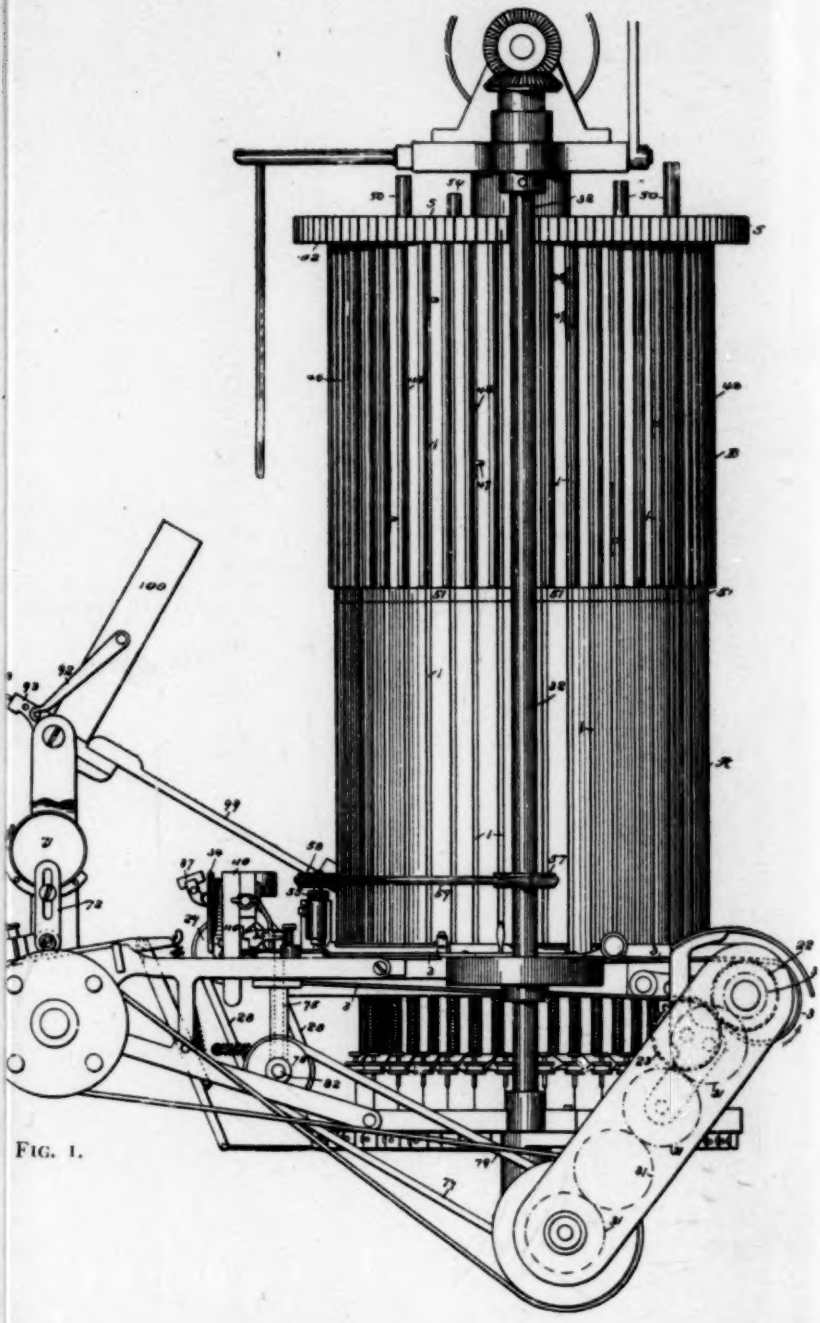


FIG. 1.

device, line after line of type is fed into the cylinder until, if desired, every groove is nearly filled, and the upper cylinder is caused to revolve upon the lower one, with which it is in contact. As the columns of mixed type pass over the heads of the shaped grooves of the lower cylinder, letter by letter falls into its proper groove, as soon as the nicks in the types find their corresponding wards. In this way, and at a speed depending on the rate at which the revolving table is driven, the types are all under perfect control of the compositor.

The invention is the subject of the following Letters-Patent of the United States.

No. 232,157, dated September 14, 1880, entitled type-setting and distributing machine.

No. 283,934, dated August 28, 1883, same title.

No. 372,186, dated October 25, 1887, same title.

No. 372,187, dated October 25, 1887, same title.

No. 387,546, dated August 7, 1888, justifying apparatus.

No. 388,088, dated August 21, 1888, justifying apparatus.

R. W. Nelson, No. 402,537, April 30, 1889, type-setting machine.

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The width of the channels in the case *B* is equal to the breadth of the body of the type, so that the type can slide down freely in them without either sticking or turning therein, the sides of the channels in the cylinder *B* being smooth plane surfaces, the type descending therein by gravitation. The rotating step-by-step motion is imparted by reciprocating pawls *13*, *6* and *10*, which engage in the notches of the ratchet wheel *5*, attached to and projecting horizontally beyond the upper end of the base *B*, being propelled by eccentrics in the upper part of the driving-shaft *64*. The first part of the motion is made by the pawl *6* very quickly, and the latter portion much slower by the pawl *13*, resting with the channels of the cylinder *A* and *B* coincident, so as to afford the best opportunity for the transfer of the type from the channels of the distributing cylinder *B* into those of the cylindric case *A*.

The channels in the case *A* are exactly equal in number and space to those of the cylinder *B*, but, instead of having plane surfaces at the sides, one side is formed with parallel steel ribs or ridges. These ridges coincide with grooves cut in the edges of the type bodies, a different location and proportion of groove being made in the body of each letter, numeral, or character, and a corresponding series of steel ridges inserted in each of the channels of the case *A*, the ridges and grooves co-operating with each other like the wards of a lock and key, and excluding from each groove all but the type of the character belonging in it, permitting the proper types to drop in. In order to distribute a form into the machine the lines of type are dropped in the channels of the upper cylinder *B*, and as soon as in the rotation the bottom type in a channel *B* comes opposite the appropriate channel in the cylinder *A*, it descends in the latter ready for use. This operation proceeds continuously and without any interference with the withdrawal and setting of type from the cylinder *A*.

At the base of each of the type channels in the cylinder *A* is placed an ejector operated by a key marked *2*, which ejects the type upon a revolving table by which they are deposited on a type-conveying belt *3*, bearing them to the left to the line-forming mechanism.

The types pass on the belt *3* to the side, and are forced into parallel position with each other and proper alignment by a striker *87*, as they travel in the slide and they are gradually turned upward by a twisted portion of the slide, that is to say, so as to present the face of the letters upward.

The types thus set are discharged in lines into a galley and, by an attendant provided with a case containing "spaces," are "justified," that is to say, the spaces between words are increased equally until the last word or, if a syllable, with its required hyphen, in each line, reaches the end of the line.

This machine it will be seen requires accuracy in construction as do also the types that are used with it, and your committee find upon personal inspection, that this hac been reduced to an exact system.

The channelling of the cylinders *A* and *B* is effected by a milling machine with an extremely accurate dividing gear for angular adjustments. The cutting of grooves in the side of the channels in the cylinder *A* is effected by milling with a small revolving cutter, guided by the line of the channels already milled out, and the steel ribs or ridges are inserted in the grooves.

The types are prepared by casting in the usual manner, are set in line, clamped in a slide, and the lines of notches or grooves upon the edges are plowed or planed in them, the accuracy of the tools employed in these operations determines the accuracy and perfect working of the machine. The grooves have been cast in the characters in several cases.

By the use of this machine, types made in the highest perfection of type-founding are used, which is not the case in the type of stereotyping or line-casting, because the differences in the form or character of different parts of the same fount of letters demand for the best perfection differences of temperature and of metal, which are regulated by the skill and care of the workman in making the type.

In handling the type by this machine, contact of the face of the letter with any of the parts of the machine is avoided, so that the best possible typography is secured by it. The only apparatus or adjunct requisite for this machine is steam-power or other propelling power. As compared with

other machines requiring the melting and cooling of metals and electric batteries for checking errors arising from the derangement of the machine, and air-currents for imparting motion to matrices or other equivalent parts, it is far simpler and superior.

The use of these machines involves the expense of the wages of these operatives, to wit: One compositor, one justifier, and one boy for distribution, per machine, and one man to set the head lines for a number of machines. A two horse-power engine drives fourteen machines.

As regularly employed in the printing office of the *Evening Post*, at Hartford, Conn. (*frontispiece*), eight operatives in one week, regular work taken at random from the pay-roll, set 1,084,834 ems. This letter was minion and brevier body. The machines are steadily at work commercially at the Publishers Printing Company, 157 and 159 William Street, New York, and in the *Evening Post*, of Hartford, Conn.; West Publishing Company, St. Paul; *Evening Journal*, Chicago; Street & Smith, New York; *The Churchman*, New York; *State Printer*, Harrisburg, Pa.; *Daily Guardian*, Manchester, England; *Daily Freeman's Journal*, Dublin, Ireland, and several other offices.

As involving fewer adjuncts and being therefore simpler, securing the best result of typography, most expeditiously and at the least cost, this machine appears to your committee to have surpassed all others in celerity and quality of work. The specimens submitted to your committee are equal to any thing procurable by printing, and in the judgment of your committee the invention deserves the highest commendation and award in the gift of the INSTITUTE.

The ELLIOTT CRESSON MEDAL recommended.

S. LLOYD WIEGAND, *Chairman.* L. L. CHEYNEY,
WM. H. WAHL.

Adopted February 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

Fig 1

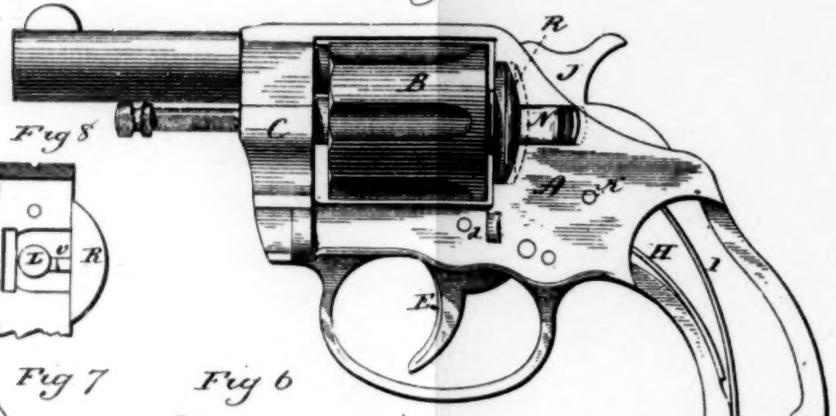


Fig 8

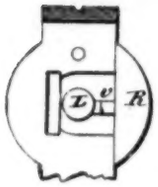


Fig 7

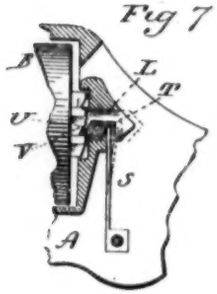


Fig 6

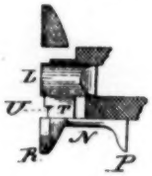


Fig 4

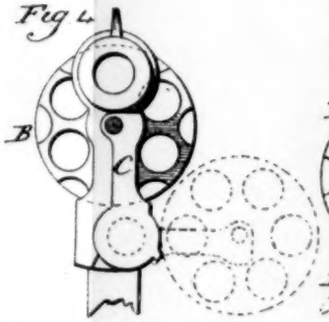


Fig 5

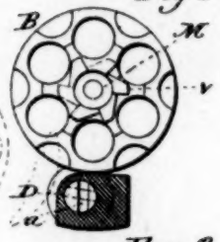


Fig 2

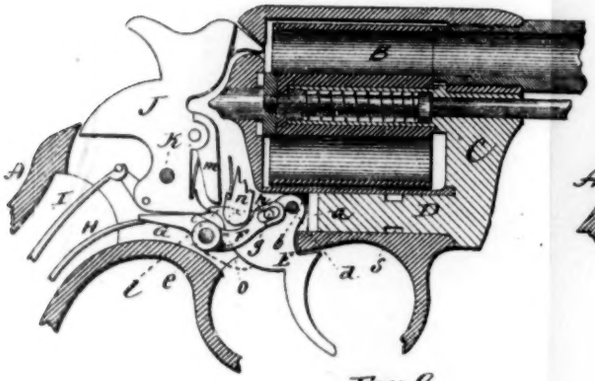


Fig 3

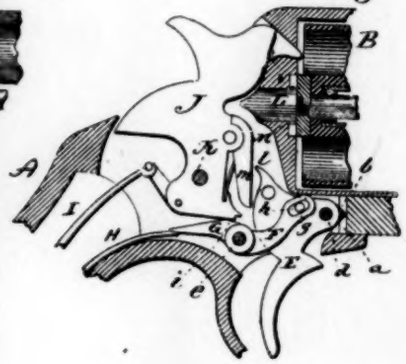


Fig 9

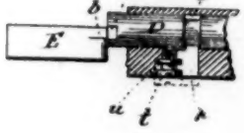
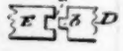


Fig 10.



COLT'S NEW NAVY REVOLVER, COMBINED WITH A NEW CARTRIDGE PACK FOR RE-LOADING.

[*Report of the Committee on Science and the Arts.*]

[No. 1,552.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 1, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

COLT'S NEW NAVY REVOLVER, COMBINED WITH NEW CARTRIDGE PACK FOR RE-LOADING SAME,

Report that: The applicant is the Colt's Patent Fire-Arms Manufacturing Company, of Hartford, Conn., the inventor being Carl J. Ehbets, an employé in the same.

The invention consists of a revolver having a solid jointless frame between the stock and the barrel, provided with a cylinder swinging laterally out of the frame and with an appliance for the simultaneous ejection of the shells. This, together with its simple self-cocking limbwork, permits of the utmost rapidity of fire, whilst preserving perfect accuracy. By means of the cartridge pack, all chambers can be loaded at once, and as the rapidity of sustained firing mainly depends upon the facilities for reloading rapidly, it forms a most important auxiliary to the revolver. The forward part of the frame is divided, a portion *C*, forming what is called the crane, this portion *C* is constructed with a spindle *D*, arranged in a corresponding seat below the cylinder, and so as to form a pivot upon which the said crane may swing laterally outward and inward. This crane carries the cylinder *B*, and a spindle formed as part of the crane in the usual manner, so that the cylinder may swing with the crane from its opening in the frame, as indicated in the broken lines *Fig. 4*, for charging the cylinder or ejecting the shells, the ejector being of common construction. In order to avoid the possible contact of the hammer with the cartridge,

except when the cylinder is in its proper position, and to prevent the outward movement of the cylinder except when the hammer shall have been so far retracted as to take its nose out of the path of the cylinder, the rear end of the spindle *D* is constructed with a vertical groove or notch *a*, which, when the cylinder is in a closed position, stands vertical and in the plane of the finger *b*, on the hub of the trigger *E* (*Fig. 9*). When the parts are in normal position (*Fig. 2*), the trigger is forward and the finger *b* stands in the plane of the groove *a* of the crane spindle, but so far to the rear of it as to be out of engagement therewith. If, however, with the parts in this position the trigger be pulled, as indicated in *Fig. 3*, the finger *b* passes into the groove *a*, of the crane spindle and interlocks therewith, so as to prevent the crane from turning. Consequently, the cylinder cannot be turned from its place in the frame except when the trigger is in its normal position. If the cylinder be thrown outward the result will be to turn the notch *a* to a plane out of the plane of the finger *b* on the trigger. Consequently, while the cylinder is in this outwardly-turned position, the rear end of the spindle serves as a stop for the trigger, and any movement of the hammer is therefore avoided. If the cylinder is not properly returned to its place, the groove *a* will not coincide with the path of the finger *b*. Consequently the trigger cannot be pulled to discharge the hammer until the cylinder is in its proper position for firing.

The bearing between the cam-shaped portion of the rebound-lever *G F*, is in such relation to the hammer, when the hammer is in the rebound position (*Fig. 2*), and the point of latch *m* extends down so as to nearly touch the top of the nose *l* of the trigger, that if the hammer should be forced forward from its rebound position, as from a fall, blow, or otherwise, the latch *m* will strike the nose *l* of the trigger, the tendency of which will be to turn the trigger forward; but, as the arm *G*, of the rebound-lever is by such accidental movement of the hammer depressed, the other arm *F* of the said lever at the same time, through the stud *g* upon the trigger, tends to turn the trigger backward against the latch *m*, and thus the hammer is positively locked, so it is

impossible to bring its nose into contact with the primer of a cartridge.

The loading pack is a device to hold cartridges in number and position corresponding to the chamber of the cylinder of a revolver, and so that cartridges arranged in such device may be together transferred to the respective chambers of the cylinder, instead of inserting the cartridges individually into the chambers of the cylinder, the object being a simple and effective device to hold the cartridges as a pack, yet so cheap in its construction that reasonable economy will admit of its being thrown away after the cartridges have been removed. The invention consists of a ring with an internal flange at one end, the internal flange at the diameter larger than the diameter at the opposite side, and with an annular groove upon the inside adjacent to the flange corresponding to the rims of the cartridges, combined with a plug adapted to be introduced through the opening in the flange, and a length corresponding to the length of the cartridges, the outer end of the plug constructed with an annular shoulder distant from the annular groove in the ring equal to the diameter of the beads of cartridges placed therein, and so that cartridges set within the ring, with flanges in the groove thereof, and the plug introduced, its inner end will bear against the cartridges near the points, and the shoulder at its opposite end will bear against the rims of the cartridges; so that the plug being forced outward will leave the cartridges free for removal from the ring.

Your committee have no hesitation in stating that they believe this arm to be the best revolving pistol that has ever been devised. It contains all the advantages of the well-known Smith-Wesson ejector system with a solid steel frame, having no break-off joint to become loose and shaky from use or repeated discharges. It is not, however, automatic like the above-named system, *i. e.*, the empty shells are not thrown out automatically when the cylinder is placed in the position for reloading. In the arm (Colt), however, the same result is effected by a slight push of the hand, and with practice, with nearly or quite as great

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rapidity. We find by means of the loading pack, the arm can be loaded in about one-third the time required when the cartridges are placed in the cylinder individually.

The safety appliances or devices in the arm are to be particularly commended. By means of the notch and finger already described, the cylinder cannot be removed from its proper position when the hammer is at full cock, and *vice-versa*, the hammer cannot be moved when the cylinder is swung out in its loading position.

By means of the lock mechanism (described in detail in the patent specifications), after the trigger has been pulled and then released, the hammer returns to its normal posi-

tion (half-cock it might be considered) from which it cannot by any ordinary means be forced down, so as to come in contact with the primer of a cartridge.

Regarding the arm as a purely military one, its scope will probably be very large, as it is vastly superior to any other arm of the kind at present in use in any country. We, therefore, believe it will be a question of time when it, or its modifications, will come into universal use for military purposes.

The tendency at the present time seems to be toward the adaptation of small calibres in all small arms, experience and careful tests has demonstrated this advantage. The

arm under consideration is thirty-eight calibre, whilst the older Colt and other revolvers of similar size and purpose vary from thirty-eight to forty-five calibres.

Your committee respectfully recommend the award of the JOHN SCOTT LEGACY MEDAL AND PREMIUM to Carl J. Ehbets, of Hartford, Conn., for his improvements in revolving fire-arms, and for the invention of the "cartridge feed-pack" for loading same.

F. LYNWOOD GARRISON, *Chairman.*
EDWIN S. CRAWLEY.
JAMES H. CARPENTER.
LUTHER L. CHENEY.
W. A. CHEYNEY.

Adopted April 2, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

APPENDIX.

The United States patents covering this improved revolving pistol and "cartridge feed-pack" for loading same, are numbers 392,503, November 6, 1888, and 402,424, April 30, 1889, respectively. Copies of the specifications and drawings of the same accompany this report.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, April 15, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 15, 1890.

Mr. W. L. Rowland, Vice-President, in the Chair.

Members present: Dr. H. W. Jayne, Dr. Wm. H. Wahl, Prof. E. F. Smith, Messrs. W. W. Macfarlane, H. A. Galt, Reuben Haines, L. E. Williams, Lee K. Frankel, H. Pemberton, Jr., W. H. Bower.

The committee appointed at the preceding meeting for the purpose of selecting journals to be subscribed for by the Section made a valuable report, which was accepted by vote of the Section.

The members of this committee were Dr. Jayne, Dr. Hooker, Mr. J. H. Eastwick and Dr. Wahl.

The journals recommended were as follows: *Bulletin de la Société Chimique de Paris, Gazetta Chimica Italiana, Zeitschrift für Physiologische Chemie, Annalen der Chemie, Chemisches Centralblatt, Zeitschrift für Hygiene, Zeitschrift für Krystallographie und Mineralogie, Tschermak's Mineralogische Mittheilungen.*

The cost of these journals was estimated, approximately, at $50.

Dr. Jayne exhibited a fragment of what had been originally a lead wall in a tank in which chloride of calcium was employed for drying purposes; the lead had been converted gradually into chloride of lead crystals. Mr. Rowland mentioned a similar case in which the transformation of lead into chloride had been brought about by common salt on board a vessel.

Mr. Pemberton called attention to a recently patented improvement in manufacturing phosphorus; by this improvement a greater output per unit of heat was claimed.

Dr. Wahl exhibited a sample of aluminium electro-plating done by the Harvey-Filley Aluminium Plating Company, of Philadelphia. He called attention to the difficulties of aluminium plating in the past, and stated that they had been practically removed.

The monthly report of Dr. S. C. Hooker, on the Philadelphia Water Supply, was read by title, and referred for publication in the JOURNAL OF THE INSTITUTE.

Adjourned.

WM. C. DAY, *Secretary.*

On the Present Condition of the Philadelphia Water Supply.

By Samuel C. Hooker.

[*Presented at the Stated Meeting of the Chemical Section, April 25, 1890.*]

Since my third report was presented to this Section, a great deal of space has been devoted in the daily papers to the discussion of our water supply, and while one cannot but regret that much has been said which is both exaggerated and untrue, it is a matter for congratulation that the subject has once again been brought prominently before the public.

During a large portion of last summer, the water supplied to all parts of the city, without exception, was almost uninterruptedly muddy. Under these circumstances it is scarcely to be wondered that there should have been a disposition to make the worst of a condition of affairs certainly bad enough without the least exaggeration. It is too much to expect that the newspapers should possess in all or even in most cases the necessary knowledge to discriminate between facts which have and others which have no weight, between arguments and opinions, which are or are not entitled to consideration, and the result has been that an immense amount of misleading information, a vast number of positively incorrect and worse than valueless statements have been distributed broadcast to the public. Facts have been dwelt upon which have no weight, self-constituted authorities have been quoted whose statements have been remarkable for their inaccuracy, positively ridiculous for their scientific absurdity.

While, however, there has been unquestionable exaggeration in the arguments used against the water, there has also been a deplorable exhibition of bias and misinformation, and a positive disinclination to admit facts on the part of certain gentlemen, who appear to regard the present condition of our water supply as all that can be desired.

For three months, after the publication of my third report, I continued the laborious investigation, the early results of which have been already communicated to you. The publication of the numerous analyses has, however, been purposely delayed, because it was thought probable that they would be more fairly and impartially considered after the excitement, created by the newspaper agitation, had subsided. My analyses did not justify me in speaking as badly of the water as several of the newspapers were able to do, and any less vehement protest against its condition would have failed at that time to have attracted the attention which I hope will now be given to this paper.

In the following table will be found, as the condensed result of my investigation, average figures for the water collected at different parts of the city during six months of last year:

Samples Collected March to September, 1889.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen of Nitrates.
West Philadelphia, Forty-fourth and Chestnut Streets (24 samples),	·233	·0015	·0080	·093
Sixteenth and Locust Streets (23 samples),	·254	·0014	·0081	·094
Twentieth Street and Columbia Avenue (23 samples),	·266	·0024	·0097	·100
Front and Bainbridge Streets (23 samples),	·265	·0013	·0076	·099
Average of 93 city samples,	·254	·0016	·0083	·097

For purposes of comparison several samples of water were taken from the Schuylkill, at Phœnixville, in order that some idea might be formed of the extent of the pollution occurring within about 25 miles of the city. The samples from Phœnixville were furnished to me through the courtesy of the Water Department. For the other samples I am indebted to the kindness of several gentlemen residing in the various neighborhoods in which they were collected, who most cheerfully undertook the troublesome task of drawing the water for analysis at stated times.

Deferring for a moment the consideration of the Phœnixville samples and judging the water by such standards as

are universally adopted, when the history of the water examined is entirely unknown, we are compelled to acknowledge that the above analyses do not in any way condemn the water, but, on the contrary, we must admit that the chlorine, free and albuminoid ammonias and the nitrates are present in quantities less than they are known to exist in many absolutely unpolluted waters.

By comparing the water at Phœnixville, however, with that supplied for city use, we are able to detect in the city water a slight increase in the quantity of the substances estimated, indicating that the sewage pollution, which we know exists, has occurred to an extent sufficient to appreciably influence the composition of the water.

The following table gives the average results of analyses of five samples of water obtained from each of the points named at nearly corresponding dates:

	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen of Nitrates.
Phœnixville (average of 5 samples),	·196	·0039	·0079	·084
West Philadelphia, Forty-fourth and Chestnut Streets (average of 5 samples),	·227	·0022	·0101	·085
Sixteenth and Locust Streets (average of 5 samples),	·264	·0017	·0099	·088
Twentieth Street and Columbia Avenue (average of 5 samples),	·242	·0027	·0126	·086
Front and Bainbridge Streets (average of 5 samples),	·260	·0012	·0078	·083

Passing on to the discussion of each of the impurities determined, we may at once dismiss the nitrates from consideration, as the quantities present in the various samples of water examined differed only slightly from each other. It will be observed that the chlorine in the water drawn at all points of the city is greater than that found in the samples from Phœnixville.

Similarly the albuminoid ammonia in three out of the four localities in the city is distinctly greater than in corresponding samples from Phœnixville. With regard to the free ammonia a decrease in quantity is observed in the city water, but in spite of this, in view of the figures for albuminoid ammonia, we are compelled to regard the

quantity of the organic substances discharged into the river after leaving Phœnixville, as somewhat greater than the combined action of the natural processes of purification and the subsiding reservoirs has been able to dispose of. During the six months covered by my investigation these impurities were almost entirely mechanically suspended, and by a suitable system of filtration could have been readily removed, leaving the water remarkably free from organic matter.

That most of the organic substances reaching the city should be pumped from the river in an insoluble form is not after all extraordinary. A considerable proportion of the organic matter of sewage exists of course in solution, but as many varieties of waste from as many factories, etc., are discharged into the river, it is probable that these substances, by acting and reacting on each other, give rise to the formation of precipitates, which in some cases may consist essentially of organic matters formerly in solution, in others which may mechanically enclose them. However this may be, the fact remains that the organic matter of the Schuylkill water, during the six months of last year that I investigated the subject, was almost and entirely in suspension and the condition of the water, deprived of its suspended matters, was entirely satisfactory, and often of a very high degree of purity.

Mud whether wholesome or unwholesome has obviously no place either in drinking water or in water to be used for household or industrial purposes, and to show, therefore, that the mud of the Schuylkill water is accompanied by precipitated organic matters derived from sewage, seems to me to add little to the many emphatic arguments, which can be already urged with unquestionable force against its presence being tolerated. But, on the other hand, by showing that practically the entire amount of the substances, which can be considered objectionable, are present in suspension and can be readily removed, leaving a water of a high degree of purity, how strong an argument we have for carrying out such purification.

In order that Schuylkill water may be filtered satisfac-

torily on a large scale, it is necessary to use a so-called "coagulant," and whether this be alum or iron, it is probable that the result will be much the same. Economical and mechanical considerations will have to be carefully weighed in choosing between them. The beneficial action of both these substances depends upon the formation of precipitates, which in the act of separation entrap and enclose the microbes and suspended particles, so that they can be arrested during subsequent filtration through sand. If the filtration be attempted without the addition of the coagulant, the very minute particles to which the turbidity of the water is due, pass through the interstices of the filter bed unchecked, but by first entrapping them in the precipitates derived from the coagulent used, they are virtually increased in size and can be arrested by the sand bed.

There is so much prejudice against alum, that it is desirable to discuss its use in the purification of water somewhat in detail. Alum is a double sulphate of aluminium and potassium and contains a large proportion of water of crystallization. Its percentage composition is as follows:

Sulphate of aluminium,	36·07
Sulphate of potash,	18·35
Water of crystallization,	45·58
	100·00

The sulphate of aluminium is the active portion of the alum and may be substituted for it if desired.

As soon as the alum is added to the water the carbonates present in solution react with the sulphate of aluminium, becoming themselves converted into sulphates with the formation of unstable carbonate of aluminium. The latter gives off carbonic acid gas and alumina separates. It is evident, therefore, that the separation of the alumina is not attended by the formation of free sulphuric acid, as has been alleged. The addition of alum to the water slightly increases the quantity of sulphates present and a small quantity of carbonate of lime is usually converted into sulphate of lime. The aluminium is entirely precipitated as alumina, and unless a considerable excess has been used, none whatever remains in solution.

I have dwelt upon the action of alum at so great a length (1) because I have been much impressed by the results which can be obtained by its use; (2) because it forms an essential feature of the American system of filtration; and (3) because I am convinced that the objections which have been urged against it are based upon an erroneous conception of its mode of action.

If it is the presence of microbes which is to be mainly feared in drinking water, there can be aside from boiling the water, no surer way of getting rid of them than by the use of a coagulant. The efficiency of iron for this purpose has been amply demonstrated at Antwerp and elsewhere; and in this country, Dr. Prudden, a well-known bacteriologist, of New York, has stated that he has found water purified by sand and alum filtration practically sterile. It has been frequently stated that microbes cannot be removed by filtration, that they will even pass a thousand abreast through the interstices of an ordinary sand-bed. In answer to this it may be said that while it is useless to look for good results by simple filtration at any speed which may be considered practical through clean sand alone, the matter is entirely changed by the use of a coagulant, and the smaller the particles, the more minute the microbes, the more surely are they entrapped in, surrounded and held by the precipitate formed.

The albuminoid ammonia in Schuylkill water, purified by sand and alum, has been often determined in my laboratory and has always fallen below ·0050 parts per 100,000.

There is scarcely a day when the water of Philadelphia does not reflect discreditably upon the city, its officials and its citizens. If we had but the one alternative, the use of the Schuylkill in its present condition or the expenditure of $20,000,000 to get water from elsewhere, we might possibly be excused for hesitation. But there are other ways of solving the difficulty. Water, considerably worse than that taken from the Schuylkill, has been successfully purified elsewhere, and why should not Philadelphia adopt a similar system of purification. It is evident that additional sub-

siding basins alone are impracticable for the work required. The enormous East Park reservoirs and the comparatively small amount of work they accomplish must have convinced all who have impartially considered the matter that some other method of purification must be adopted. The suspended matters of the Schuylkill water are mostly so minute and are deposited so slowly that very many times our present storage capacity would be necessary to render the condition of the water at all times uniformly clear and satisfactory. The large number and large size of the reservoirs required to do this and the immense outlay which their construction would involve would seem to be sufficient reason for looking to other methods of purification.

In conclusion, I desire to acknowledge my indebtedness to a gentleman who wishes to be nameless, not only for the interest he has taken in the progress of this investigation, but also for liberally sharing the expenses connected with it.

A complete list of my unpublished analyses of the Schuylkill water is appended.

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Chlorine expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
May 24th,	—	·18	·28	·22	·30
31st,	—	·21	·25	·28	·24
June 7th,	—	·19	·20	·22	·20
14th,	—	·22	·24	·24	·24
21st,	—	·27	·26	·26	·31
26th,	·22	—	—	—	—
28th,	—	·27	·30	·33	·31
July 5th,	·16	·21	·26	·19	·23
12th,	—	·21	·23	·25	·22
19th,	—	·19	·20	·18	·20
26th,	—	·24	·24	·26	·26
August 1st,	·16	—	—	—	—
2d,	—	·21	·24	·15	·25
9th,	—	·21	·23	·26	·23
16th,	—	·20	·24	·19	·22
23d,	·18	·22	·24	·23	·21
30th,	—	·25	·23	·34	·28
September 6th,	—	·20	·28	·31	·30
7th,	·26	—	—	—	—
Mean of the above 16 analyses, May 24th—September 6th,	·196	·217	·245	·244	·250

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Free Ammonia expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
May 24th,	—	·0010	·0005	·0090	·0010
31st,	—	·0005	·0010	·0035	·0005
June 7th,	—	·0000	·0010	·0080	·0005
14th,	—	—	—	—	—
21st,	—	·0017	·0005	·0015	·0020
26th,	·0012	—	—	—	—
28th,	—	·0049	·0010	·0049	·0010
July 5th,	·0079	·0027	·0022	·0030	·0012
12th,	—	·0005	·0015	·0030	·0005
19th,	—	·0017	·0017	·0022	·0050
26th,	—	·0040	·0025	·0020	·0017
August 1st,	·0054	—	—	—	—
2d,	—	·0012	·0044	·0030	·0022
9th,	—	·0007	·0052	·0027	·0022
16th,	—	·0022	·0027	·0067	·0030
23d,	·0040	·0000	·0002	·0015	·0002
30th,	—	·0007	—	·0025	·0030
September 6th,	—	·0024	·0007	·0015	·0015
7th,	·0010	—	—	—	—
Mean of the above determinations,	·0039	·0016	·0015	·0028	·0016

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Albuminoid Ammonia expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
May 24th,	—	·0090	·0060	·0115	·0055
31st,	—	·0100	·0100	·0100	·0120
June 7th,	—	·0070	·0060	·0050	·0060
14th,	—	—	—	—	—
21st,	—	·0130	·0055	·0110	·0120
26th,	·0060	—	—	—	—
28th,	—	·0109	·0089	·0160	·0069
July 5th,	·0080	·0160	·0169	·0190	·0160
12th,	—	·0060	·0100	·0080	·0069
19th,	—	·0086	·0095	·0112	·0105
26th,	—	·0084	·0085	·0092	·0065
August 1st,	·0112	—	—	—	—
2d,	—	·0122	·0092	·0154	·0082
9th,	—	·0079	·0074	·0090	·0097
16th,	—	·0150	·0084	·0104	·0102
23d,	·0072	·0050	·0069	·0054	·0044
30th,	—	·0044	·0089	·0062	·0042
September 6th,	—	·0067	·0077	·0045	·0037
7th,	·0074	—	—	—	—
Mean of the above determinations,	·0079	·0093	·0086	·0107	·0081

ANALYSES OF THE PHILADELPHIA WATER SUPPLY.

Nitrogen of Nitrates expressed in parts per 100,000.

1889.	Phœnixville.	West Philadelphia.	Sixteenth and Locust Streets.	Columbia Avenue.	Front and Bainbridge Streets.
July 12th,	—	·098	·08	·108	·106
19th,	—	·092	·108	·08	·096
26th,	—	·11	·08	·13	·11
August 1st,	·064	—	—	—	—
2d,	—	·08	·098	·05	·092
9th,	—	·104	·08	·10	·108
16th,	—	·084	·078	·076	·104
23d,	·096	·088	·072	·108	·082
30th,	—	·103	·089	·110	·10
September 6th,	—	·088	·094	·10	·076
7th,	·092	—	—	—	—
Mean of the above analyses,	·084	·094	·086	·095	·097

NOTES AND COMMENTS.

CHEMISTRY.

THE RELATIVE ABUNDANCE OF THE CHEMICAL ELEMENTS. F. W. Clarke, Philosophical Society of Washington (*Bulletin*, **11**, 131).—The author has calculated the percentage composition of the known matter of the globe. In order to have a definite mass of matter under consideration, he assumes for the earth's *known* crust a thickness of ten miles below sea level.

Composition of the Earth's Crust includes Ocean and Air.

Oxygen,	49·98
Silicon,	25·30
Aluminium,	7·26
Iron,	5·08
Calcium,	3·51
Magnesium,	2·50
Sodium,	2·28
Potassium,	2·23
Hydrogen,	0·94
Titanium,	0·30
Carbon,	0·21
Chlorine, Bromine,	0·15
Phosphorus,	0·09
Manganese,	0·07
Sulphur,	0·04
Barium,	0·03
Nitrogen,	0·02
Chromium,	0·01
	100·00

That nine elements should constitute, at the lowest estimate, ninety-eight per cent. of all terrestrial matter is somewhat startling. The comparative

rarity of carbon and sulphur is, to say the least, surprising. With regard to the high position of titanium in the list, the author says: "Titanium is rarely absent from the older rocks; it is almost universally present in soils and clays, and it is often concentrated in great quantities in beds of iron ore. Having no very striking characteristics, and but little commercial importance, it is easily overlooked, and so it has a popular reputation for scarcity which it does not deserve."

Taking the density of the earth's crust as 2·5, the author gives the following figures:

Percentage of atmosphere,	·03
Percentage of ocean,	7·08
Percentage of solid crust,	92·89
	100·00

Since the known nitrogen of the earth is mainly in the atmosphere, its relative scarcity as an element is at once made curiously manifest.

S. C. H.

On Gantler's Method of Estimating Tannin. By Henry R. Proctor, *Jour. Society of Chemical Industry*, **9**, 260.—The original paper, by F. Gantler, appeared in *Zeitschr. für angw., Chem.*, 1889, 20, and was translated in the Journal of Society of Dyers and Colorists, **5**, 176. Gantler suggests the use of a solution of permanganate of about 4 grams per litre. He acidifies 10 cc. of the tannin infusion with 10 cc. of dilute sulphuric acid, and adds the permanganate in small quantities to the nearly-boiling solution, pausing between each addition till decoloration takes place. When in the end a precipitate of manganese hydrate forms, which no longer disappears, even on vigorous boiling, about 1 cc. of permanganate is added in excess, and the strong boiling is repeated several times, which causes the disappearance of the red color and the separation of a dense brown precipitate. This is then removed by the addition of a known quantity of oxalic acid and the titration completed in the usual way without boiling, and the permanganate equivalent to the oxalic acid is deducted. Gantler shows by a series of experiments that one gram of pure tannin consumes 3·988 grams of permanganate, and he states that the amount reduced by other tannins is not very different, but on this point he is experimenting further.

Proctor finds on trying Gantler's method that the amount of permanganate consumed is materially influenced by the excess of permanganate added, and by the amount of boiling to which it is submitted. In this way he obtained with an infusion of oak bark results varying from 17·6 cc. to 19·8 cc. permanganate, and concludes that by a rigid scheme of operation the new method might give concordant results, but such results could have at best but a comparative value, and no greater claims to accuracy than those of the Löwenthal method.

H. T.

ENGINEERING.

The Cantilever Bridge, spanning the Firth of Forth, Scotland, was opened on Tuesday, March 4, 1890, by the Prince of Wales. The two main

spans are 1,710 feet each, making it the largest span bridge in the world. Sir Wm. Arrol and Sir Benjamin Baker, the engineers, have received the honors of knighthood in recognition of their skill and services in this colossal work. L. M. H.

THE NEW OMNIBUS LINE on Broad Street is so objectionable on account of the noise that the services in schools, churches and halls are seriously interrupted, and the inmates of hospitals, and the sick seriously affected. Numerous petitions have therefore been presented, requesting the substitution of an asphalt pavement for the existing one of Belgian block.

Desirable and urgent as this may be it is of still greater importance to the city to improve this opportunity to secure subways before the new pavement is laid, and thus avoid the disgraceful and constant irruptions of the streets. This can readily be obtained by granting privileges to parties to construct an ample and sufficient subway for rapid transit, and all municipal and private mains, wires, and service pipes, for which this route is particularly well adapted. The parties securing this franchise would no doubt repave with asphalt, without cost to the city. In this connection it may be well to note that, in view of the experience elsewhere, we believe it to be a serious mistake to lay the *side* bearing iron girder rails, now being put down on Ninth Street, instead of the *grooved* girder rail; but it is said that there is no alternative, as the city ordinances require a rail upon which ordinary vehicles may "track." If this be so, it should be changed at an early date, since it is the cause of many broken wheels and axles, and injury to both track and pavement, *vide* Market Street and many others. L. M. H.

MISCELLANEOUS.

IN VIEW of the interest manifested in the intention of the authorities of the State of New York to inflict the death penalty upon criminals condemned for capital offences by electrical agency, the considerations advanced by Prof. Houston are worthy of attention.

This author, in a brief communication, entitled "On Muscular Contractions following Death by Electricity," read before the American Philosophical Society, February 7, 1890, presented his views on the subject in the following terms:

Accurate data are wanting as to whether death resulting from accidental contact with electric conductors conveying the powerful currents employed in systems of electric lighting or power distribution is, or is not, practically instantaneous. Certain facts, however, are known which show that when the nature of the contacts is such that the discharge passes through the respiratory, the cardiac or the brain centres, that true physiological death, as evidenced by the complete failure of these centres to perform their normal functions, and their inability to afterwards perform these functions, is practically instantaneous.

In cases of death from a lightning bolt, for example, instances are on record where death has been so immediate that the bodies have remained

so nearly in the positions occupied during life that passers-by have failed to recognize the presence of death.

On the regaining of consciousness lost by a lightning discharge or a contact with an electric conductor, the subject, as a rule, has no memory of pain or suffering, and in many instances is even ignorant of the cause of the accident.

A fact, however, which appears to disprove that practically instantaneous physiological death follows a powerful electric discharge, should be alluded to. In some instances, it has been observed that the body of the person receiving the discharge showed prolonged convulsive muscular contractions and contortions. The question thus arises, Do such muscular movements necessarily prove actual suffering on the part of the subject? Do they even necessarily prove the existence of life while they are taking place? While, of course, the answer to this question must necessarily be to a certain extent uncertain, the following considerations are offered to show that in all probability such muscular contractions follow physiological death, and are, therefore, unattended by consciousness or suffering.

Two general cases of contact resulting in death may occur, viz:

(1) A momentary contact, where the discharge is only temporary, as in the case of the lightning discharge, or the case of a person falling against the wires and remaining in contact therewith but a few seconds or fractions of a second.

(2) A prolonged contact where the current continues to pass through the body for some time after death.

In cases of death by the first class of contacts, no convulsive movements occur. Death results from physiological shock, or possibly from changes in the nervous or muscular tissues.

In the second class of contacts, death in many cases probably occurs practically instantaneously. The question then arises, How can the muscular contractions be explained?

The classic experiments of Galvani with the excited legs of recently killed frogs prove conclusively that the passage of an electric current causes convulsive muscular movements. The same phenomena, too, have been observed in the human subject, as numerous experiments with the bodies of criminals shortly after their execution have shown.

It would seem, therefore, probable, to say the least, that when the electric current continues to pass through the body of the subject after physiological death has occurred, though such convulsive muscular movements may occur, and that, therefore, their existence do not prove suffering.

When a powerful current traverses the body, tetanus occurs, and muscular movements in such parts cease. The nerve loses its sensibility, and, if the current is too strong, changes occur in its structure or composition, either as a result of polarization, or electrolysis, or otherwise, which prevent it from being further affected by the electric discharge. Since such changes presumably occur in cases of death by electric discharges, it would appear that muscular contractions would, therefore, be impossible after death. A brief

consideration of the manner in which an electric current traverses the human body will show that such a conclusion is unwarranted.

When the electrodes of any source are applied to any two parts of the human body, a current passes through the body from the positive to the negative electrode. The density of current that passes, or the current strength per unit of area of cross-section, is different at different parts of the body. Those portions that lie in the paths of least resistance, which, in general, are situated in paths of least distance between the electrodes, receive the denser and more powerful current, while those lying in paths of greater resistance receive weaker currents. In other words, in the passage of the electric current through the human body, a diffusion of the current occurs.

While, therefore, the nerves and muscles lying in the direct path of a fatal discharge may be almost instantly deprived of their sensibility by the passage of the powerful and fatal discharge through them, the nerves and muscles which lie in the paths of less powerful currents may still retain their power of electric excitation.

It is, therefore, probable that in cases of prolonged fatal contact with electric conductors, the ensuing convulsive muscular contractions do not of necessity prove suffering.

I offer these views, with some diffidence, from the standpoint of an electrician rather than from that of a physiologist.

BOOK NOTICES.

ELECTRICAL DISTRIBUTION OF LIGHT, HEAT AND POWER. By Harold P. Brown, Electrical Engineer. New York: J. W. Pratt & Son, No. 73 Fulton Street.

This little pamphlet is a reprint of an address by Harold P. Brown, entitled "A Medico-Legal View of Electrical Distributions," delivered before the International Medico-Legal Congress, held at Steinway Hall, New York, June 4, 1889; and also an address by John Murray Mitchell, entitled "Legislative Control of Dangerous Electrical Currents," read before the same Congress. To these is appended "A Partial List of Deaths from Electric Lighting Apparatus."

The purpose of the pamphlet substantially is to impress the reader with the fact that alternating currents are far more dangerous to life than direct currents, and to urge the restriction by law of the use of high-tension currents. In reading between the lines, however, it is very evident that bitter enmity exists between Mr. Brown and the Westinghouse Electric Company.

After quoting the officials of several companies operating alternating currents, whose statements were to the effect that the alternating current, while disagreeable, is perfectly safe up to and even exceeding 1,000 volts, Mr. Brown mentions a number of instances in which people have been killed by

coming in contact with insulated wires carrying an alternating current of 1,000 volts.

He then explains the object of his efforts briefly as follows: "Since the risk in the public use of a deadly agent is increased a thousand-fold if its promoters sell it as safe, I feel that I am justified in using all possible means to educate the public to distrust both the system and its owners. This, in connection with the bitter personal attacks made upon me, is the cause of my activity in the matter."

The explanation of the various methods of electrical distribution is very good; the "water analogues" of which are particularly commendable, as apt illustrations of these systems, to laymen. The statement, however, that "the ampère" is "the unit of current volume," and comparing it with "the amount of water flowing through a pipe," is not only misleading, but incorrect.

Mr. Brown then attacks the claims of the Westinghouse Company as to the efficiency of their system, and cites several tests in which the alternating system was far less economical than the direct-current system.

There is also a calculation which shows that the Westinghouse system requires about eighty per cent. more copper wire than the Edison three-wire system for the same number of lamps. Mr. Brown then makes an eloquent appeal for legislation to prevent *deadly* currents, stating that since boilers, plumbing work, storage of oil, powder, etc., are restricted and controlled by the authorities, there is no reason why deadly currents of electricity and leaky dynamos should not be also.

A partial list of deaths caused by high tension direct and alternating currents is given, containing the names of the deceased, place and date of accident, and the kind of current. It shows that in seven years sixty-four persons were killed by the direct current, and in two years, with one-tenth the number of dynamos, twenty-seven persons were killed by the alternating current.

The address by Counsellor John Murray Mitchell, which follows in the pamphlet, contains abstracts, from various sources, showing the illegality of anything prejudicial to public health; the limitation of electrical pressure imposed in London, and the right of our government to place similar restrictions. It also contains a proposed bill for preventing the generation and use of deadly electric currents, except for the execution of criminals, as required by law, or for experimental purposes.

The pamphlet is interesting and well worth reading, as it contains much circumstantial evidence showing the dangerous character of alternating currents, and is a worthy appeal for restrictive legislation. H. H.

NOTES ON QUALITATIVE ANALYSIS. Arranged for the use of students of the Rensselaer Polytechnic Institute. Troy, N. Y.: Nims & Knight. 1889.

To lead students to gain a fuller knowledge of chemical phenomena, the author adds to a rather meagre collection of tests a number of experiments that are to be made by the students. They are expected to explain the

observed phenomena, and for their assistance, numerous references to journals and text-books are given. The introduction of references is a good feature, but nearly all of the experiments form a part of the elementary laboratory work of colleges and technical schools. Another salient feature of the book is its extreme conciseness. The reactions to be performed are few, many important acids are not mentioned, and no general scheme for the detection of acid residues is to be found. In following the method given for the analysis of metals and alloys, many students would fail often to find either antimony or tin. While these notes may be suited to the conditions that called them forth, the book can hardly be called better than some of its predecessors. L. B. H.

A TEXT-BOOK OF ASSAYING. For the use of those connected with mines. By C. Beringer and J. J. Beringer. Philadelphia: J. B. Lippincott Company. 1890.

This is indeed, as it claims to be in the preface, a handy book for the assayer, and brought entirely up to date. It is entirely devoid of speculative chemical philosophy, and yet it does not neglect even the rarer substances when they affect the result of an assay. The authors remind us that it is difficult, and becoming more and more so, to distinguish between an assayer and an analyst. The book is systematically and well divided into, *Part 1*, I, a preliminary portion covering definitions, sampling, drying, methods of calculating and forms of recording, with exercises in each; II, dry gravimetric methods; III, wet gravimetric methods; IV, volumetric assays; V, weighing and measuring; VI, reagents; VII, formulæ and equations, specific gravity. *Part 2*, IX, silver, gold, platinum, mercury; X, copper, lead, thallium, bismuth, antimony; XI, nickel, iron, zinc, cadmium; XII, tin, tungsten, titanium; XIII, manganese, chromium, etc.; XIV, earths, alkaline earths, alkalies. *Part 3*, XV, oxygen and oxides, halogens; XVI, sulphur and sulphates; XVII, arsenic, phosphorus, nitrogen; XVIII, silica, carbon, boron, appendix, tables of contents and for conversion of measures, etc. The illustrations are clear and easily comprehended, for the most part. We heartily agree with the authors in discarding the use of proper names to indicate a process, for reasons that they do not give in their preface. Firstly, the number of processes is too great to burden the mind of a beginner with distinctive words for them. Then, many of their processes are modified, either by the original author or by others, so that it is not clear exactly what is meant. This book is a welcome addition to technical literature. F.

CONVERSATION ON MINES, ETC., BETWEEN A FATHER AND SON, ETC. By William Hopton. Reprinted from the Eighth English Edition. Philadelphia: J. B. Lippincott Company. 1890.

This reversion to a form of didactic literature, which was popular in the early life of our fathers, is likely to repel one, for however excellent the contents of a work may be, one cannot help reaching satiety at the wisdom and respectful deference, and the tirelessness of the youth who plies his parent with questions through 178 pages of print. The object, of course, is to break

the monotony of a treatise, and to stop and help the learner over the difficulties of the question, but just here is where the system is a delusion. The difficulties to one person are seldom the same as to another, and nothing is more unsatisfying than to find that what is unclear to you has been accepted by the other boy as perfectly intelligible, while a large space is given to explanations of what had never given you any trouble. Still there is much excellent matter in the treatise which intending mine officers would do well to read.

The next 123 pages of the book are devoted to conversation, or rather responses to a Board of Examiners. The last twenty-two pages are filled with anecdotes of miners.

It is a grave book for youths' amusement and instruction, written by an honest and experienced man. F.

A HAND-BOOK OF ENGINE AND BOILER TRIALS, AND OF THE INDICATOR AND PRONY BRAKE. By R. H. Thurston, M.A., LL.D., Dr. Eng'g. New York: John Wiley & Sons. 1890. pp. xii, 514.

This latest work of Prof. Thurston brings together in good shape a large amount of valuable data which, while generally familiar to engineers, has been practically of but little use. The methods of testing given are those in use by the best engineers, and the apparatus to be used and the methods of using are fully set forth. Most engineers who have been conducting trials for any length of time have fallen into the method of testing which seems to them best, with but little regard to the work of others. Certain data are always taken, but to allow of comparison between tests, all the data that can be taken should be noted. A careful reading of this work cannot fail to increase the accuracy and completeness of engineering work in this line. In Chapter I, the objects sought in test trials are given. Chapters II and III treat of steam boiler trials, giving the standard tests and the rules governing them, as prepared by a committee of the American Society of Mechanical Engineers, together with the "log" and report blanks, and numerous other forms, and blanks that the author has found convenient in his own practice. The calorimeter ordinarily used, the apparatus for analyzing flue gases, measuring chimney draught, testing gauges and measuring the temperature at the base of the chimney, are described, and the methods of making the necessary calculations are explained. The subject is closed with a sample test of a water tube boiler.

Chapters IV to VII, inclusive, treat of the indicator, and the various methods of measuring power transmitted or absorbed. A description of all the indicators in common use, and the methods of standardizing and testing the indicators are given. The various methods of attaching and connecting up the indicator are shown, the precautions to be taken in using the apparatus, and the blank forms printed on the back of the cards are given. Diagrams for different kinds of engines and the different sorts of diagrams that can be taken for the same engine, with the use of each diagram, are illustrated. The method of measuring the diagram and the apparatus used

is described, and the methods of taking the revolutions with the various devices used for the purpose are given. The method of calculating the steam and water consumption, of drawing the hyperbolic curve and the effect of cylinder condensation and leakage are explained. A description of the Morin Webber and Emerson transmitting dynamometer, and of the various forms of Prony brake, some good and some bad, and a method of designing a brake for large powers are given

Chapters VIII and IX treat of engine trials, showing the method of fitting an engine up for test, the regulations for competitive engine, boiler and pump trials, and the methods of trial in common use for steam, gas and vapor engines.

Example are given of tests of stationary, portable, locomotive, marine and pumping engines and boilers, and of gas and vapor engines. The data in the reports of these various trials are exceedingly valuable, apart from the purpose of the author in using them as examples of various kinds of tests.

There are numerous tables at the end of the work, giving about all the quantities required in making tests.

From the above *résumé* of its contents, it will be seen that it is an exceedingly valuable work for engineers. H. W. S.

THERMODYNAMICS, HEAT MOTORS AND REFRIGERATING MACHINES. By De Volson Wood, C.E., M.A. Third edition. New York: John Wiley & Sons. 1889.

The treatment of the theoretical part of the work is practically the same as in the earlier editions. In its more practical aspects the work is now greatly improved. The air engines of Ericcson and Stirling are analyzed, as in the second edition, in an approximate but very satisfactory manner; the air transferred from one side of the piston to the other, and called the working air, being supposed of constant weight, and treated as though entirely separated from the cushion air. The gas engine is treated as in the other editions, and might be made more exhaustive. The discussion of the naphtha engine is a discussion of some experiments made on an engine of this kind. The subject of steam injectors is taken up; the theory is first given with an example showing the application, and approximate formulæ are given. The injector is compared with a direct-acting pump. A description of a pulsometer and an analysis are given. The compressed air engine and compressor are treated of rather freely. An attempt is made to solve the problem of the steam turbine, but not a very satisfactory one. Refrigerating machines are taken up and dealt with from a practical standpoint. A few pages at the end of the text treat of combustion.

The appendices are the same as in the earlier editions. The first one, on the Luminiferous Ether, adds so many pages without increasing the value of the work. The second, on the "Second Law of Thermodynamics," and the addenda following could have been with advantage put in their proper places in the text.

One of the interesting parts of the work is the application of the principles

of thermodynamics to determining some of the properties of ammonia, which gives a method of procedure which can be followed for any vapor, and shows the experimental data which must be obtained before the work can be undertaken. There is only one objection to be made to the author's method, and that is to his method of determining the constants in his equations. For instance, the author gives a table, showing the results of Regnault's experiment on the volumes and pressures of ammonia gas at 8°·1 C. He assumes that

$$p\,v = a\,\tau - \frac{b}{\tau\ v^n}$$

where a, b and n are constants, p the pressure and v the volume of the gas at a temperature $\tau°$. Then taking but three of the experiments, he deduces values of a, b and v, which he uses. In another place we have for the relation between pressure and temperature of saturated vapor

$$log_{10}\,p = 6{\cdot}2495 - \frac{2196}{\tau}$$

and again for the same thing—

$$log_{10}\,p = 6{\cdot}2469 - \frac{2200}{\tau}$$

the constants being probably deduced in the same way and then changed arbitrarily. Again, an equation is given for the density of liquefied ammonia in terms of the temperature.

$$d = {\cdot}6364 - {\cdot}0014\,t$$

which was evidently written from inspection of a table, showing the relation for each 5° from — 10° to + 20° C.

Values of these constants could easily be obtained, which would much more nearly express the results of the experiments, and would greatly increase one's faith in the tables deduced.

But this matter aside, which is not of very great moment, the work now is in good shape for a text-book and afterwards for a reference-book. The principles are clearly set forth, and are constantly being applied to practical problems, the data for which in many cases are taken for actual tests or experiments, and the results of the calculations are compared with the actual results obtained from the apparatus. H. W. S.

ANNUAL REPORT OF THE DIRECTOR OF THE DRAWING-SCHOOL OF THE FRANKLIN INSTITUTE FOR THE SESSIONS 1889–1890.

The condition of the school during the sessions, which close this evening, has been very satisfactory. The number of pupils has exceeded by thirty-seven that of the same period last year, and, owing to the re-arrangement of the class-rooms, this larger number has been as well accommodated in one body on two evenings per week as the smaller number was when divided into two sections and occupying the rooms four evenings. This concentration has added zest and vigor to pupils and instructors and has been beneficial in every way. The interest displayed by the great majority of the pupils has been very encouraging and it is a source of gratification to know of the marked improvement in the abilities and qualifications of many of them, which has been brought about by their devotion of a very limited amount of time at this night-school.

The tendency of the instruction has been more towards a thorough instilling of underlying principles and correct methods than to elaborate and difficult execution, for which the time is entirely too short. The effort has been to make the most profitable use of this time, so that the result will be a correct foundation and outline, upon which the pupil can build up and fill in according to his opportunities, abilities and energy. One result of this system is, that the drawings exhibited here this evening are largely of so technical a character as not to be generally appreciated nor understood. They are not the work of engineers, architects and artists, made for the purpose of display, but merely that of pupils, made while obtaining principles and methods. They do not fairly represent what the pupil can do, nor adequately indicate what he has learned and the training and impulses which have been given him. I consider our time to have been much better employed than if it had been devoted to obtaining from each pupil a highly-finished drawing (the execution of which would occupy the entire term), for the purpose of making a display which would be striking and effective in a popular sense. The great majority of the pupils attend for the purpose of gaining instruction and information, which will be of use to them in their daily work and which will increase their ability to fill higher positions, and the school is conducted mainly with a view to the accomplishment of this purpose.

The corps of instructors during the last year has included Messrs. Clement Remington, Percy Ash, George W. Irons, Willis H. Groat, William Paterson, George S. Cullen, John Rowland and Lucien E. Picolet, and the excellence of the school has been largely due to their abilities and zeal.

The following pupils are entitled to HONORABLE MENTION:

In the Junior Classes.

Edward C. Aitken, Thomas S. Worn,
George Lukens, Thomas Hayter,
George T. Coleman.

In the Intermediate Classes.

H. Allen Higgins,
Walter Nagle,
Charles Kolb,
James L. Garnett,
W. A. Leavitt, Jr.,
Frederick Koeberle,
Dinwiddie J. Luckett,
James Mawson,
A. Somers Kapella,
Charles J. Rooke,
D. O'Brien,
Frank A. Butz.

In the Senior Mechanical Class.

John S. Rooke,
Rudolph G. Fleischman,
A. Albertson,
Frank S. Thompson,
Lawrence H. Kellogg.

In the Architectural Class.

Howard M. Craig,
Emile G. Perrot,
George C. Tilton,
Ida M. Marple,
Morgan Hall, Jr.

In the Free-Hand Class.

Robert F. Schleicher,
George Lethy,
Benjamin F. Dauphin,
George Leonard Koch,
John G. Lisburger.

The following pupils are awarded SCHOLARSHIPS from the B. H. Bartol Fund, entitling them to tickets for the next term, beginning September 23, 1890:

John S. Rooke,
H. Allen Higgins,
Walter Nagle,
Howard M. Craig,
Dinwiddie J. Luckett,
Edward C. Aitken.

The following pupils, having attended a full course of four terms, with satisfactory results, are awarded CERTIFICATES to that effect:

A. Albertson,
Frank Blatz,
Donald Frazer,
Charles W. Godfrey,
Walter Gray,
Robert G. Hienerwald,
Charles F. Kennedy,
Leonard George Koch,
Edmund May, Jr.,
Harvey W. Moyer,
Robert F. Schleicher,
Charles H. Speckman,
Charles E. Steger,
William E. Wilkinson,
Peter Armbruster,
Gustav Fiedler,
Richard T. Given,
William Gonser,
Harry Harres,
Alice M. Jester,
David A. Kelley,
Lawrence H. Kellogg,
John G. Lisburger,
Walter A. McCaffrey,
John S. Rooke,
John L. Steele,
George C. Tilton,
Alfred Edwin Yates.

The next term of the school will begin September 23, 1890, with the same organization and system, and every effort will be made to increase the usefulness and efficiency of this department of the INSTITUTE.

WILLIAM H. THORNE,
Director.

THE ANNUAL CEREMONIES attending the presentation of certificates to the members of the graduating Drawing Class were held in the hall of the FRANKLIN INSTITUTE, on Thursday, April 24th, at 8 P.M., Vice-President Mr. CHAS. BULLOCK presiding. Of the officers and ex-officers of the INSTITUTE were present: the Secretary, Dr. WAHL, Prof. COLEMAN SELLERS, Prof. E. J. HOUSTON, Prof. PERSIFOR FRAZER, Dr. ISAAC NORRIS and Mr. WASHINGTON JONES.

Addresses to the students were made by Prof. SELLERS, Mr. THOS. SHAW, Prof. FRAZER, and Prof. HOUSTON; and a very large and creditable display of the drawings made by the pupils was exhibited on the walls. At the conclusion of the addresses, the certificates, duly sealed and signed, were delivered by Prof. THORNE to those entitled to them.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, April 16, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 16, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, 128 members and thirteen visitors.

Additions to membership reported since last meeting, nine.

The actuary in presenting the report of the Board of Managers announced a vacancy in the office of Vice-President, caused by the death of Mr. FREDERIC GRAFF. The President stated that the Board of Managers had already taken suitable steps to do honor to the memory of its deceased member, and had appointed a special committee to prepare a memorial for publication in the JOURNAL.

An election to fill the vacancy in the office of Vice-President resulted in the election of Mr. EDWARD LONGSTRETH.

Prof. H. W. SPANGLER, Chairman of the Committee on Science and the Arts, presented a brief statement of a recent discussion by the Committee of the subject of the JOHN SCOTT LEGACY, PREMIUM AND MEDAL, and moved

that the documents relating thereto, and which were in possession of the Secretary, be referred to the Board of Managers. Carried.

The President alluded to the fact that this was the eve of the 100th Anniversary of the death of the great philosopher BENJAMIN FRANKLIN, whose honored name the INSTITUTE bears, and made some appropriate remarks thereon.

The Secretary reported a vacancy in the Committee on Science and the Arts, caused by the resignation of Mr. RUFUS HILL.

Dr. EDWARD F. MOODY was elected to fill the vacancy.

Dr. M. L. DAVIS, of Lancaster, Pa., read a paper descriptive of the method of incinerating the bodies of the dead in the furnace devised by him, and used by the Philadelphia Cremation Society and other similar societies. The paper was illustrated with the aid of the projecting-lantern.

Mr. WALTER HART, of New York, followed with a description of his improved "Clutch Hoist," and exhibited the operation of the apparatus as a boat lowering and hoisting device.

The Secretary yielded place to Mr. W. N. JENNINGS, who presented an interesting series of photographic views, showing the devastation wrought by the tornado that lately visited the city of Louisville, Ky.

Under unfinished business Mr. SAMUEL SARTAIN was elected as Trustee of the ELLIOTT CRESSON MEDAL FUND, to fill the vacancy caused by the resignation of Mr. FRED'K FRALEY.

In view of the Secretary's statement that the election of Mr. S. LLOYD WIEGAND as Trustee of the same fund, had been found not to have been made in strict accord with prescribed regulations, the irregularity was thereupon corrected by the re-election of that gentleman.

Adjourned. WM. H. WAHL, *Secretary.*

LIST OF SERIAL PUBLICATIONS AND PERIODICALS PRINCIPALLY RECEIVED IN EXCHANGE FOR THE JOURNAL AND WHICH ARE ON FILE IN THE LIBRARY OF THE FRANKLIN INSTITUTE.

A

Academia Nacional, ... Cordova.
Academie Royale de Belgique. Bulletin, ... Bruxelles.
Academy of Natural Sciences. Proc., ... Philadelphia.
Age of Steel, ... St. Louis.
American Agriculturist, ... New York.
Analyst, ... "
Anthropologist, ... "
Architect and Building News, ... Boston.
Artisan, ... Chicago.
Builder and Woodworkers' Journal, ... Philadelphia.
Cabinet Maker, ... Boston.
Chemical Journal, ... Baltimore.
Chemical Society. Journal, ... New York.
Engineer, ... Chicago.
Exchange and Review, ... Philadelphia.
Farmer, ... Baltimore.
Garden, ... New York.
Gas Light Journal, ... "
Geographical Society, ... "
Geologist, ... Minneapolis.
Iron and Steel Association. Bulletin, ... Philadelphia.
Journal of Mathematics, ... Baltimore.
Journal of Medical Sciences, ... Philadelphia.
Journal of Pharmacy, ... "
Journal of Photography, ... "
Journal of Railway Appliances, ... New York.
Journal of Science, ... New Haven.
Machinist, ... New York.
Mail and Export Journal, ... " "
Manufacturer and Iron World, ... Pittsburgh.
Meteorological Journal, ... Detroit.
Miller, ... New York.
Monthly Microscopical Journal, ... Washington.
Naturalist, ... Philadelphia.
Philosophical Society. Proc., ... "
Society of Civil Engineers, ... New York.
Society of Mechanical Engineers, ... "
Stationer, ... "
The, ... Philadelphia.

Analyst, ... London.
Annalen der Physik und Chemie, ... Leipzig.
Annales de Chimie et Physique, ... Paris.
des Mines, ... "
des Ponts et Chaussées, ... "
des Travaux Publics, ... "
Industrielles, ... "
Anthony's Photographic Bulletin, ... New York.
Architekten- und Ingenieur-Verein. Zeitschrift, ... Hanover.
Army and Navy Journal, ... New York.
Artisan, The, ... Cincinnati.
Association of Charcoal Iron Workers. Journal, ... Philadelphia.
of Engineering Societies, ... New York.
Astronomie, L', ... Paris.
Athenæum, ... London.

B

Baltimore Underwriter, ... Baltimore.
Bankers' Magazine, ... New York.
Bayerisches Industrie- und Gewerbeblatt, ... Munich.
Berg- und Hüttenmännische Zeitung, ... Berlin.
Bibliothèque des Archives, ... Paris.
Bibliotheca Nazionale, ... Firenze.
Book Chat, ... New York.
Boston Journal of Commerce, ... Boston.
British Journal of Photography, ... London.
Builder, ... "
and Decorator, ... Philadelphia.
and Real Estate Advocate, ... "
and Woodworker, ... New York.
Builders' Exchange, ... Boston.
Weekly Reporter, ... London.
Building, ... New York.
Builder, ... Philadelphia.

C

Canadian Institute. Proc., ... Toronto.
Patent Office Record, ... Ottawa.
Record of Science, ... Montreal.
Carpet Trade and Review, ... New York.
Carriage Monthly, ... Philadelphia.
Centralblatt für Electrotechnik, ... Munich.
Century, ... New York.
Chemical News, ... London.
Trade Journal, ... "
Society. Journal, ... "
Chronique des Travaux Publis, ... Bruxelles.
Industrielle, ... Paris.

Cincinnati Society of Natural History, ... Cincinnati.
Collegio degli Ing. ed Arch., ... Milano.
Colliery Engineer, ... Pottsville.
Compagnie Générale Transatlantique, Journal, ... Paris.
Comptes Rendus de l'Academie des Sciences, ... "
Connoisseur, ... Philadelphia.
Cosmos, ... Paris.

D

Decorator and Furnisher, ... New York.
Deutsche Chemische Gesellschaft, ... Berlin.
Verkehrs-Zeitung, ... "

E

Education, ... Boston.
Electric Age, ... New York.
Electrical Engineer, ... London.
Review, ... New York.
World, ... "
Electrician, ... "
Electrician, ... London.
Électricien, L', ... Paris.
Électricité, L', ... "
Electrotechnische Rundschau, ... Halle.
Zeitschrift, ... Berlin.
Electrotechnischer Anzeiger, ... "
Engineer, ... London.
Engineer, ... Kiew.
Engineer, ... New York.
Engineering, ... London.
and Building Record, ... New York.
and Mining Journal, ... "
News, ... "
Engineers' Club. Trans. and Proc., ... Philadelphia.
English Mechanic and World of Science, ... London.

F

Franklin Institute. Journal, ... Philadelphia.

G

Gaceta Industrial, ... Madrid.
Garden and Forest, ... New York.
Gas World, ... London.
Génie Civil, ... Paris.
Geological Society, Quarterly Journal, ... London.
Survey of India. Records, ... Calcutta.
Giornal del Genio Civil, ... Rome.

H

Herapath's Railway Journal, ... London.

Horological Journal, ... London.
House Painting and Decorating, ... Philadelphia.
Humboldt Library, ... New York.

I

Illustrated Official Journal, ... London.
Illustrirtes Oesterreich-Ungarisches Patentblatt, ... Wien.
Il Politecnico, ... Milano.
Index to Periodicals, ... New York.
Industria e Invenciones, ... Barcelona.
Industria, L', ... Milano.
Industrial Review, ... Philadelphia.
Industries, ... London.
Indian Engineer, ... Calcutta.
Ingeniors Forenigens Forhandlingar, ... Stockholm.
Inland Architect and News Record, ... Chicago.
Institution of Mechanical Engineers, ... London.
Istituto R. di Studii Superiori, ... Firenze.
Iowa State Board of Health. . . . . .
Iron, ... London.
Iron, ... Philadelphia.
Age, ... New York.
and Coal Trades Review, ... London.
Ironmonger, ... "

J

Johns Hopkins University Circulars, ... Baltimore.
Journal du Gaz et de l'Électricité, ... Paris.
de Physique, ... "
des Usines à Gaz, ... "
für Gas-Beleuchtung, ... Munich.
für Praktische Chemie, ... Leipzig.
of Analytical Chemistry, ... Easton.
of Education, ... Boston.
of Fabrics, ... Halifax.
of Gas Lighting, ... London.
of Industry, ... San Francisco.
of Microscopy and Natural History, ... Bath.
of Mycology, ... Manhattan.
of Progress, ... Philadelphia.
of the New York Microscopical Society, ... New York.
of the Telegraph, ... "

K

K. K. Geologische Reichsanstalt, ... Vienna.
Knowledge, ... London.

L

Library Journal, ... New York.
Light, Heat and Power, ... Philadelphia.

Lippincott's Magazine, ... Philadelphia.
Literary News, ... New York.
Lock and Bell, ... "
London, Edinburgh and Dublin Philosophical Magazine, . . . London.
Lumber World, ... Buffalo.
Lumière Électrique, ... Paris.

M

Macon, Ga., Mortality Report, ... Macon.
Manufacturer, ... Philadelphia.
and Builder, ... New York.
and Inventor, ... London.
Manufacturers' Chronicle, ... Pittsburgh.
Gazette, ... Boston.
Review, ... New York.
Manchester Geological Society, ... Manchester.
Marine Engineer, ... London.
Merchant World, ... New York.
Mechanical News, ... "
Progress, ... London.
Mechanic, ... Smithville.
Mechanics, ... New York.
Medical and Surgical Reporter, ... Philadelphia.
Metal Worker, ... New York.
Meteorologische Zeitschrift, ... Berlin.
Michigan State Board of Health, ... Lansing.
Microscope, ... Detroit.
Miller, ... London.
Millers' Gazette, ... "
Journal, ... New York.
Review, ... Philadelphia.
Miller and Manufacturer, ... Cincinnati.
Milling Engineer, ... Milwaukee.
World, ... Buffalo.
Millstone, ... Indianapolis.
Mining and Scientific Press, ... San Francisco.
Institute of Scotland. Trans., ... Hamilton.
Journal, ... London.
Modern Light and Heat, ... Boston.
Miller, ... Kansas City.
Monatshefte für Chemie, ... Wien.
Moniteur Industrielle, ... Paris.
Scientifique, ... "
Monthly Weather Review, ... Washington.
Musée Teyler, ... Haarlem.

N

Nashville, Tenn., Health Reports, ... Nashville.

National Association Wool Manufacturers. Bulletin, ... Boston.
Car and Locomotive Builder, ... New York.
Nature, ... London.
La, ... Paris.
Newark Mortality Reports, ...
New Haven Mortality Reports, ...
Orleans Mortality Reports, ...
York Medical Journal, ... New York.
York Microscopical Society, ... "
Norske Ingenior og Arkit, Forenigen, ... Kristiana.
Teknisk Tidskrift, ... "
North American Review, ... New York.
Carolina Health Reports, ...
of England Institute of Mining Engineers, ...
Northwestern Miller, ... Minneapolis.
Nouvelles Annales de Construction, Oppermann, ... Paris.

O

Oakland, Cal., Health Reports, ...
Oesterreichischen Ing. u. Arch. Verein, Zeitschr., ... Wien.
Ingenieur Verein, ... "
Oesterreichisch-Ungarisches Patent-Blatt, ...
Oil, Paint and Drug Reporter, ... New York.

P

Paper and Press, ... Philadelphia.
Trade Journal, ... New York.
Patent Amt, ... Berlin.
Patent Office Gazette, ... Washington.
Pennsylvania Magazine, ... Philadelphia.
Philadelphia Carpet Trade, ... "
Phonetic Journal, ... London.
Photographic Times, ... New York.
News, ... London.
Politecnico, Il, ... Milano.
Polyclinic, ... Philadelphia.
Polytechnisches Journal, ... Stuttgart.
Popular Science Monthly, ... New York.
News, ... Boston.
Portfeuille des Machines. Opperman, ... Paris.
Printers' Circular, ... Philadelphia.
Power-Steam, ... New York.
Power and Transmission, ... Mishawaka.
Practical Engineer, ... London.
Practische Maschinen Constructeur, Der, ... Leipzig.
Progressive Age, ... Philadelphia.
Publication Industrielle, ... Paris.

Publicazione Italiane, ... Firenze.

R

Railroad and Engineering Journal, ... New York.
Gazette, ... "
Railway Age, ... Chicago.
News, ... Philadelphia.
Register, ... St. Louis.
Review, ... Chicago.
World, ... Philadelphia.
Revue Générale des Chemins de Fer, ... Paris.
Inter. de l'Électricité, ... "
Scientifique, ... "
Roller Mill, ... Buffalo.
Royal Astronomical Society. Proc., ... London.
Geographical Society. Proc., ... "
Institution. Proc., ... "
Microscopical Society, ... "
Scottish Society of Arts, ... Edinburgh.
Society of London. Proc., ...
Russian Imperial Technical Society, ... St. P't'rsb'gh.

S

San Francisco Health Reports, ...
Sanitarian, ... New York.
Sanitary Record, ... London.
School of Mines Quarterly, ... New York.
Schweizerisches Gewerbe-Blatt, ... Zurich.
Science, ... New York.
Scientific American, ... "
Supplement, ... "
News, ... Boston.
Société Belge d'Électriciens. Bulletin, ... Bruxelles.
D'Encouragement pour l'Industrie Nat., ... Paris.
de Géographie de Marseille. Bulletin, ... Marseille.
Paris. Bulletin, ... Paris.
Società degli Ingegneri e degli Architetti, ... Roma.
Société de Géographie de Tours, ... Tours.
des Sciences Industrielles de Marseilles, ...
des Ingénieurs Civils. Memoires, ... Paris.
Industrielle de Mulhouse. Bulletin, ... Mulhouse.
Internationale des Électriciens, ... Paris.
Scientifique Industrielle de Marseilles, ...
Society for Psychical Research, ... London.
of Arts. Journal, ... "
Chemical Industry. Journal, ... "
Dyers and Colorists, ... "
Telegraph Engineers, ... "

Spectator, ... New York.
St. Louis Miller, ... St. Louis.
Photographer, ... "
St. Nicholas, ... New York.
Stahl und Eisen, ... Düsseldorf.
Stationary Engineer, ... Chicago.
Statistical Society. Journal, ... London.
Stoves and Hardware, ... St. Louis.
Street Railway Journal, ... New York.
Sugar Beet, ... Philadelphia.
Cane, ... Manchester.

T

Techniker, ... New York.
Teknisk Tidskrift, ... Stockholm.
Technology Quarterly, ... Boston.
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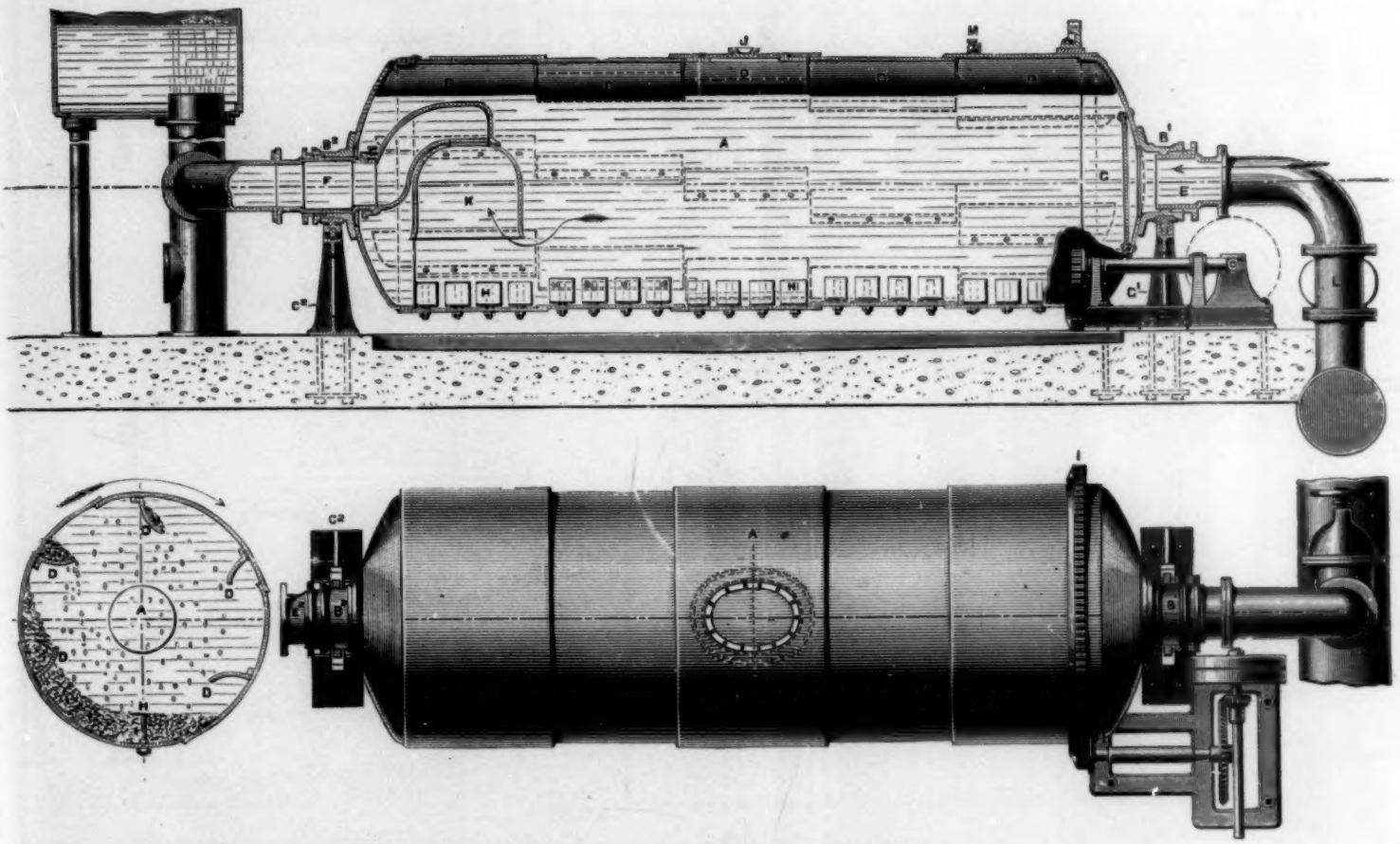
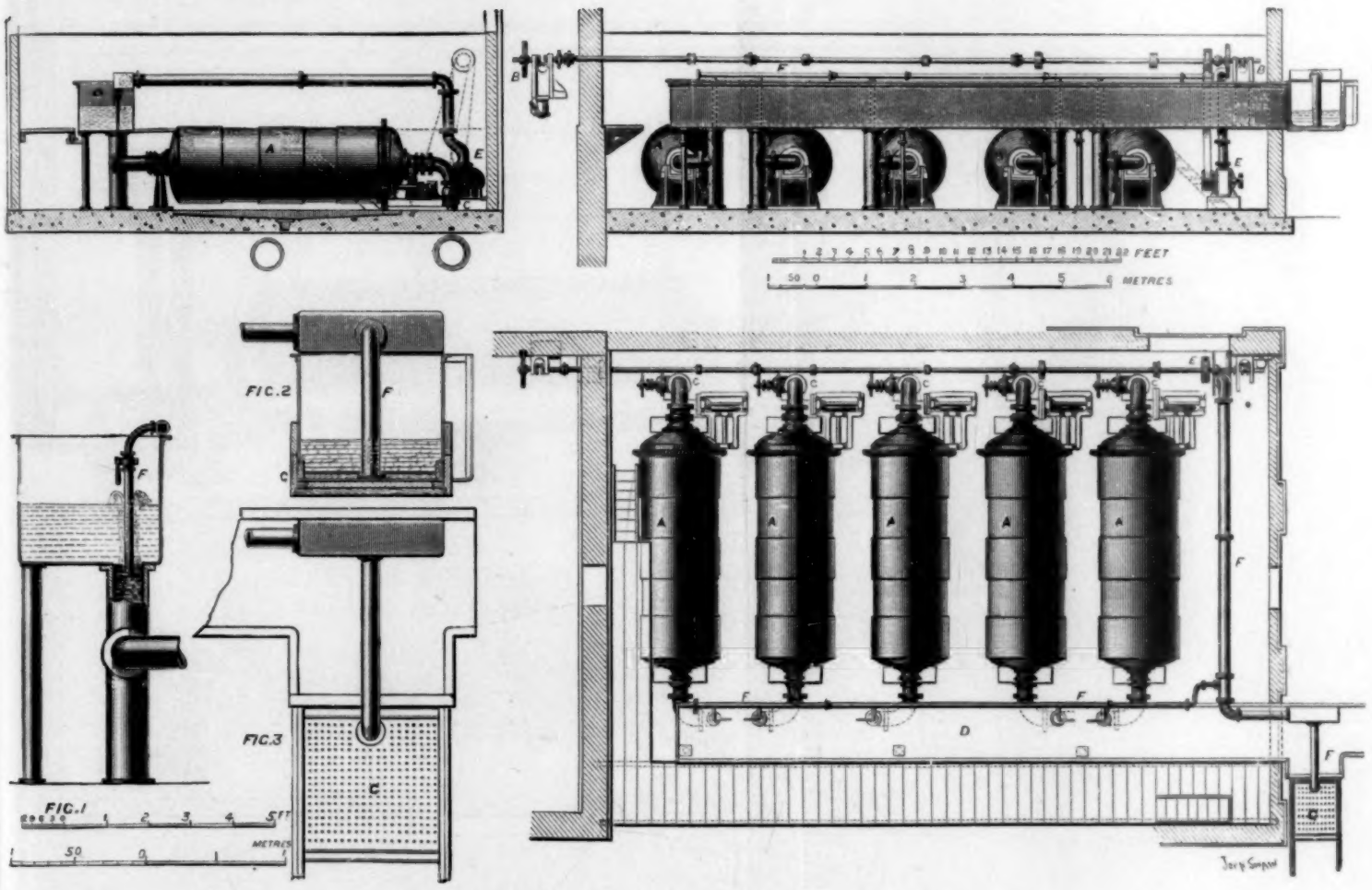
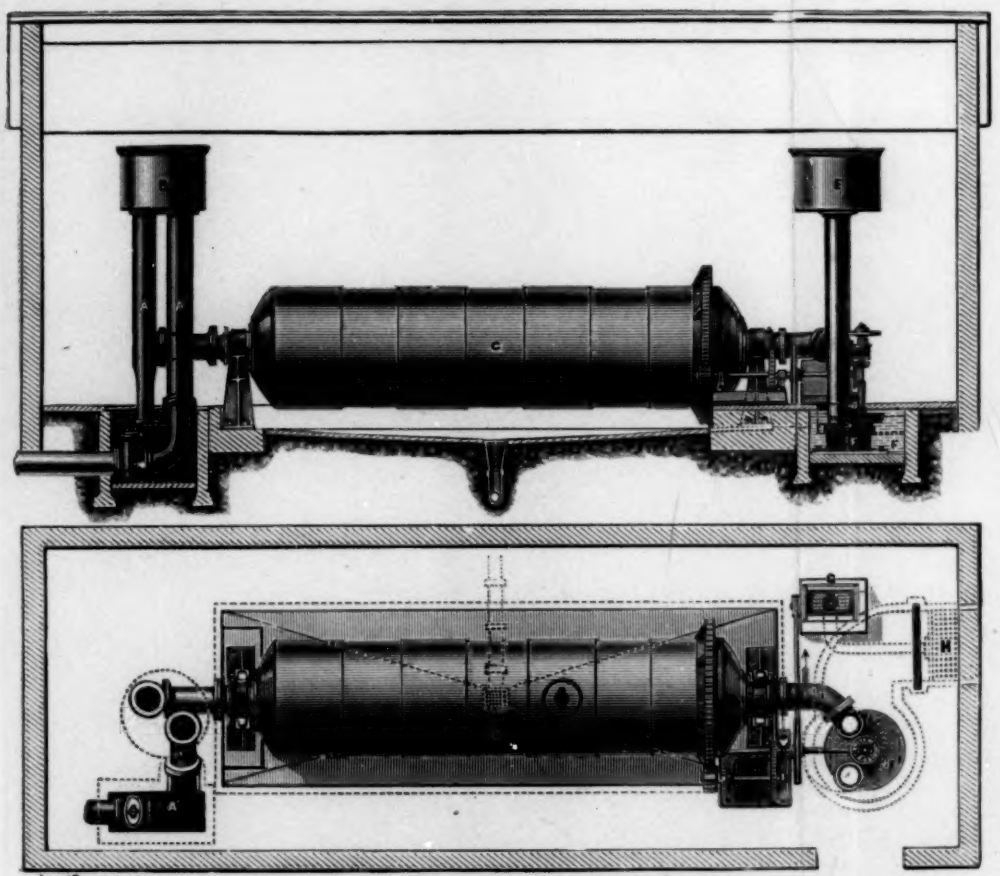
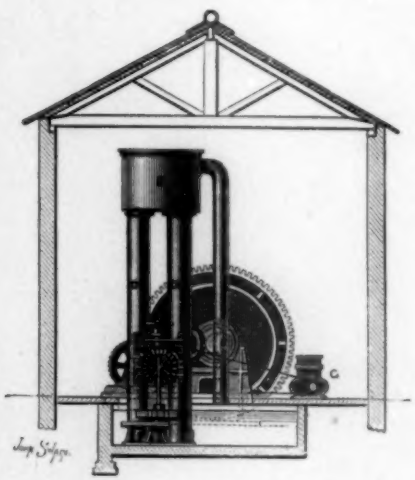


Plan and Elevation of Anderson's Revolving Purifier.



Arrangement of Revolving Purifiers at the Antwerp Waterworks.





Plan and Elevation of Revolving Purifier, with Turbine and Blower.

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